HOME

ENERGY

GUIDE

Minnesota Department of Commerce
Energy Information Center

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HOME ENERGY GUIDE

TECHNIQUES TACTICS & TIPS

Low Cost & No Cost Energy & Money Saving Ideas

Minnesota Department of Commerce Energy Information Center

Saving energy in your home doesn't require a major investment of money—or even your time. This HouseWarming guide offers ideas that will cost you little or nothing. Some will save you a lot of money, others perhaps only a few dollars a year. But add them up and you could reduce your annual energy bill by 25 percent or more.

More details on these front page tips

More low cost & no cost energy saving ideas.

Got a minute? Save hundreds of $$$

Some of the ideas on this page won't even take that long, but can save a typical home owner at least $100 to $200 a year.

Home Heating

- You've heard it before, but the savings make it bear repeating: Turn down the thermostat. Reduce the temperature from 70° to 65° while you're home, and turn it down to 60° or 55° while you're away or asleep, and cut your heating bill by about 25 percent.
- Close a bedroom door and heat register during the day, or close off an unused room entirely, and save about $50 a year.
- Open shades to let in the sun's warmth–close them at night to keep heat inside.
- Lock Windows. It tightens the seal to stop heat leaks.

Water Heating

- Turn down the temperature setting. You may be surprised how low you can turn your water heater and still get water hot enough to serve your needs–all you need is 120° to 125°.
- A dripping hot water faucet can cost over $35 a year. Fix it. Usually all it takes is a new washer.
- A water-saving showerhead can save $40 a year.

Appliances

- Turn up the temperature a little in your refrigerator and save quite a few dollars.
- If you need a new refrigerator, take a minute to ask the dealer about energy efficient models. The savings are astounding.
- Save half the energy your dishwasher uses by not using the dry cycle.
- Turn off/unplug appliances you're not using, especially while you're away for a few days (don't forget the water bed, it's a real energy hog).

Related Guides:
Home Heating
Home Cooling
Appliances
Home Insulation
Lighting
Water Heaters

Energy Myth:

Turning down the thermostat doesn't save energy because it takes as much energy as was saved to reheat the house.

Fact:

The bigger the difference between indoor and outdoor temperatures, the faster heat escapes your house. So when you turn down the thermostat, the indoor temperature is closer to the outdoor temperature—you lose less heat—the furnace runs less— you save a lot of energy.

Tips to Lower Your Heat Bill

Heating is the biggest part of a Minnesotan's home energy bill. There are several free (or very inexpensive) things you can do to lower your heating costs.

The thermostat

Turn it down. To explain the potential savings by way of example: If you currently keep your thermostat at 70° and spend $800 a year to heat your home–you could save around $150 to $250 by reducing your normal setting to 65° and setting it back an additional 10° at night and while you're away.

Furnace maintenance

With a warm air system, clean or replace the furnace filter every month during the heating season. An even slightly dirty filter will block air flow and send heat up the chimney instead of into your home.

Keep easily accessible mechanical parts clean if you know how to first turn off the electricity to the furnace for safety purposes.

Turning the pilot light off during the summer can save over $30 a year. Only do this if you are confident you can do it safely by following directions on the furnace or instructions from a service person.

Have your gas or oil furnace professionally cleaned and tuned every year.

Radiators and warm air registers

Air in radiators keeps them from filling with hot water and operating at peak efficiency. To fix this, use a radiator key (about 50 cents at a hardware store) to open the valve near the top of the radiator. As soon as water starts to come out, close the valve. Add water according to your service manual or ask a service person.

Don't block radiators with furniture, drapes or other objects.

Keep the radiator clean with a thick, soft bristled radiator brush (available at most hardware stores).

A radiator enclosure can improve efficiency if it leaves room for air circulation. There should be a one or two inch space between the radiator and the enclosure and between the back of the enclosure and the wall.

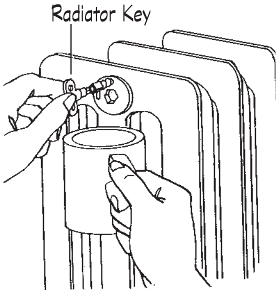
An alternative to an enclosure is a simple piece of cardboard covered with aluminum foil, mounted on the wall behind the radiator. This reflector will send heat back into the room that otherwise would be lost through the back wall.

Warm air registers should also be kept clear of obstructions and vacuumed occasionally.

Insulate pipes and ducts

Water pipes to radiators and warm air ducts to registers should be insulated. Use foam wrap on pipes and fiberglass batts on ducts.

Check all seams for leaks while the blower is on. Seal leaks in cold air return and supply ducts with metalized duct tape.



Check-List for Professional Furnace Servicing

Before hiring someone to clean and tune your furnace, run through this checklist to make sure these items are included in the service.

- Clean, lubricate and check belts and pulleys in the blower system of a forced-air furnace.
- Perform a test for carbon monoxide.
- Check the combustion air inlet for proper sizing and make sure the supply of combustion air is sufficient.
- Inspect and clean the flue, chimney and connections from the furnace to the chimney.
- Check burn performance and adjust if needed.
- Clean the heat exchanger and inspect it for cracks or warpage.
- Check the blower fan on-off settings to make sure they are set for maximum efficiency.
- Check the fuel supply and fuel line filter in oil burning furnaces.
- For boilers, all the above measures should be taken, plus lubricating and cleaning the pump system and expansion tank.
- Include a safety and efficiency check on your water heater.

Remember to ask the service person to recommend and demonstrate some routine maintenance measures you can take to keep your furnace running efficiently between service calls.

Water Heating Tips

Water heating is usually the second largest part of your energy bill. A typical Minnesota family or four, heating with natural gas, will spend about $200 a year for hot water. With electricity, it's about $450 a year. The following suggestions can easily reduce your water heating bill by one-fourth or more.

Insulate the water heater tank and hot water pipes

Insulating your water heater and pipes keeps heat from escaping and the project will easily pay for itself in less than a year, even with a new water heater.

Use foam wrap to insulate hot water pipes throughout the house. Also insulate the cold water pipe for the few feet nearest the heater. For safety, keep foam insulation three inches away from the heater drafthood and exhaust vent.

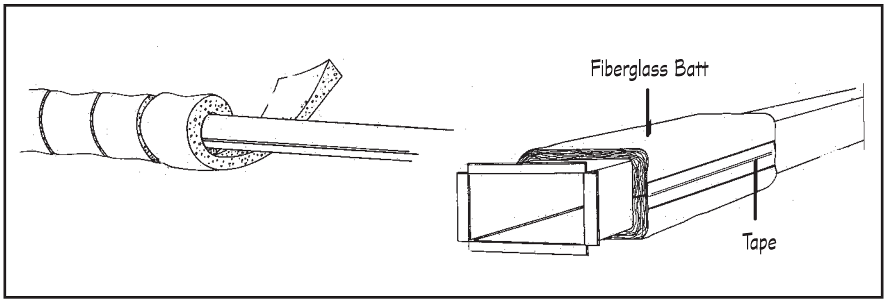
Wrap your water heater tank with a blanket of fiberglass insulation. Water heater insulation kits are widely available at minimal cost. When wrapping a natural gas water heater, leave the top and the area near the bottom open so the pilot and burner can have air and the heater will draft properly. Leave the control panel on both electric and gas water heaters uninsulated.

Turn down the temperature

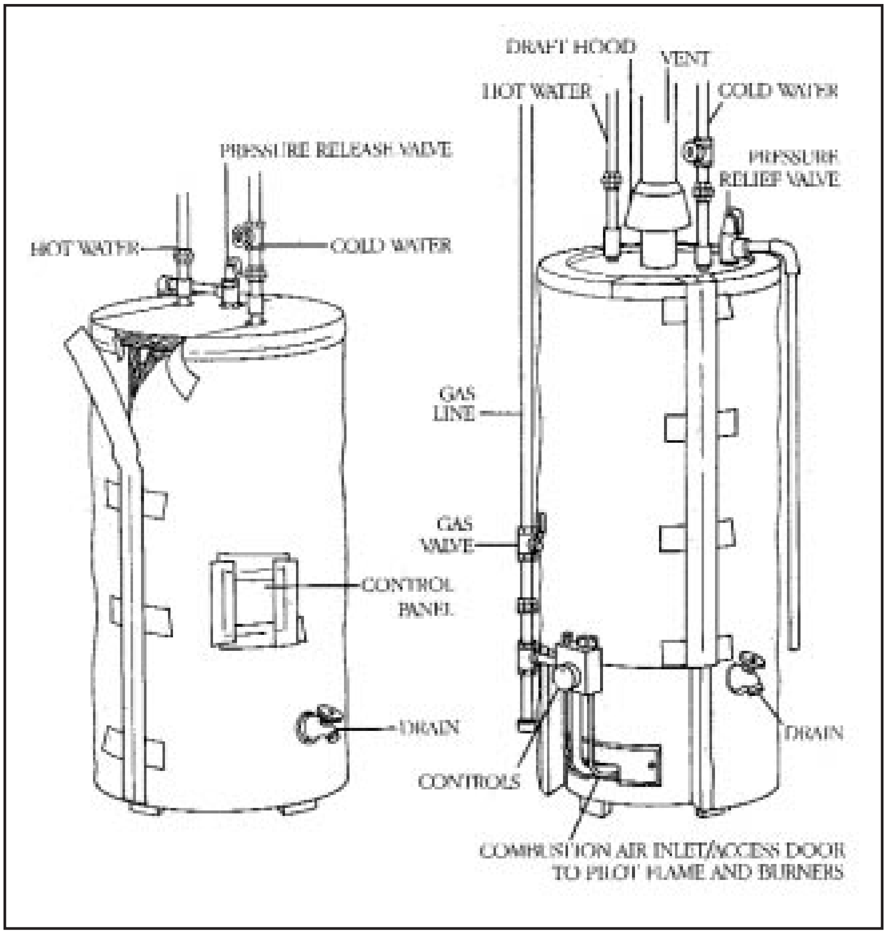
You don't need the water to be any hotter than 120 or 125 degrees. Any higher setting not only wastes energy but also creates a risk of scalding, especially for children. If you water heater doesn't have specific temperature settings, use a cooking thermometer to measure water temperature at your sink or bath to determine how far toward the low setting you can turn it and still get water above 120.

Fix leaky faucets

A hot water faucet leaking only one drop per second will waste 60 gallons of hot water a week and cost you about $35 dollars a year. Leaks can usually be fixed by replacing the tap washer. Turn off the water below the sink or tub (or at the main supply), take the faucet apart and replace the bad washers. (Note: Many newer style "washerless" faucets cannot be taken apart as shown in



Foam wrap pipe insulation and insulate ducts with fiberglass batts.



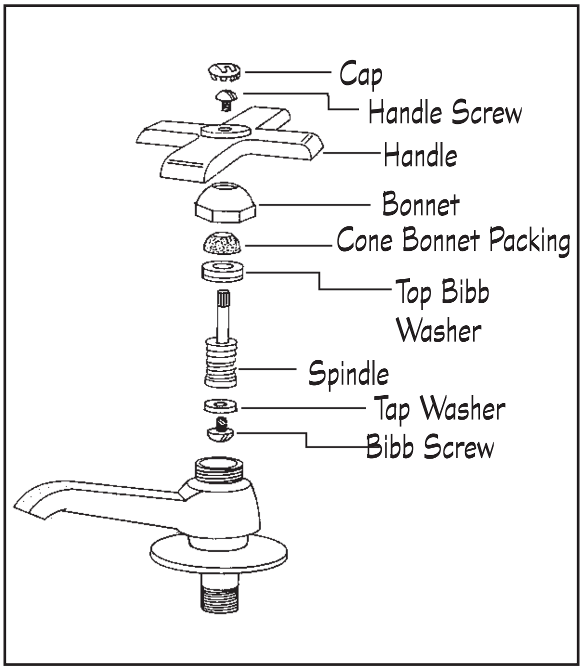
Insulate waterheaters. Electric water heater is shown on left and gas water heater on right.

Energy Myth:

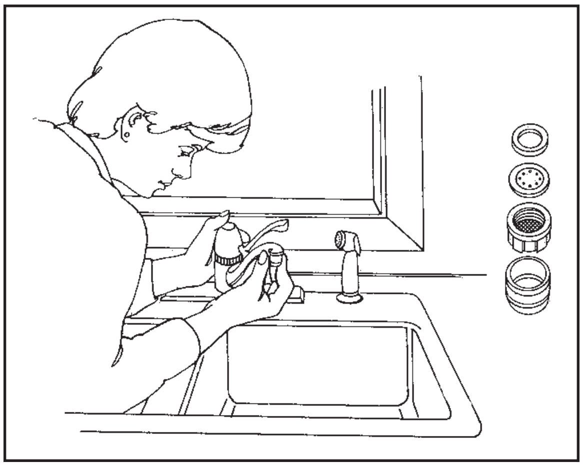
You need really hot water to sterilize dishes and clothes.

Fact:

Even at the hottest setting on your water heater, your dishes and clothes are not sterilized.



Disassembled faucet.



Put aerators and flow restrictors on faucets.

the accompanying illustration. If a leak can't be fixed by tightening or replacing the aerator or washer at the end of the faucet, the internal mechanism in the "washerless" faucet is probably worm out and the entire unit may have to be replaced.)

Install low flow aerators on faucets

Low flow aerators on faucets will save you money on both your water bill and water heating costs. They reduce the amount of water you use without a noticeable change in the flow. Aerators cost from one to five dollars. To install, simply unscrew the standard aerator at the end of the faucet and install the low flow device. If you don't have aerators, consider installing them–they are well worth the effort.

Install a water-saving showerhead

A water-saving showerhead uses about two gallons of water a minute which is about six gallons less than a conventional showerhead. This will save a typical household using gas to heat water over $25 a year and over $45 a year with an electric water heater. Water-saving showerheads cost anywhere from $8 to $40 depending on the style and provide very comfortable showers. To install, remove the old showerhead with a wrench, put a little pipe joint compound on the threads of the spigot and screw on the new showerhead.

Other easy hot water saving tips

- Take showers instead of baths. They use much less water–close the drain next time you shower–you'll see that this is true.
- Don't let the hot water run while shaving. You, in fact, get a closer shave with cold water.
- If you have an electric water heater, check into "time of day rates." This involves having your water heater come on only during "off-peak" times. Contact your utility's customer service office for details and see if this would work for you.
- Turn you water heater down to the lowest possible setting if you are going to be away for a few days.

Lighting Energy Saving Tips

Electric lights account for about 10 to 15 percent of your electric bill. You can save money on lighting with little or no effort or cost. The best way is to turn off lights when they're not needed and to not overlight areas. Take a walk through your house and see where you can make these energy savings changes:

- Use "task lighting" wherever possible. In other words, use a small lamp for reading or working–light the subject instead of the entire room.
- Don't use "long-life" incandescent bulbs. They're less energy efficient than ordinary bulbs, giving off less light per watt.
- For areas that need a great deal of light, use one large wattage bulb instead of several small ones (one 100-watt bulb actually provides more light than two 60-watt bulbs).
- Use fluorescent lights where possible, they're much more efficient. Compact fluorescent lamps will fit into normal light sockets and will save you about $40 over the life of the bulb.
- When buying bulbs, check the package for information. Light is measured in lumens–you want the most lumens per watt.
- Dimmer controls and three-way switches on lamps can reduce energy use by allowing you to select the lighting levels sufficient for your needs.

Saving Energy in the Kitchen

The refrigerator

The refrigerator is only a single appliance, yet by itself it is typically the third largest part of your energy bill. If you are facing a major repair bill on an older model, it's probably wise to invest that money in a new refrigerator. Today's new energy efficient models will easily cut at least $100 a year from your electric bill. All new models come with information on energy use. Use this information in your buying decision. Meanwhile, here are several things you can do to help reduce your refrigerator's energy consumption.

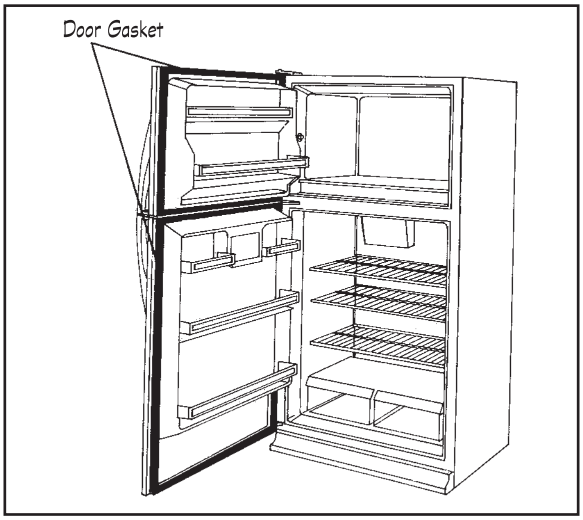
- Make sure the gasket between the door and compartment seals tightly by closing the door on a dollar bill and tugging on it. There should be resistance when you pull on the bill. Do this in several spots around the door. If you find a loose area, you might only have to clean the gasket. If it is loose or torn, you may be able to fix it with glue. If it can't be fixed, contact a dealer that handles you model and get a new gasket.
- Keep the coils on the back or at the bottom of the refrigerator clean and cool to keep it working at peak efficiency. Periodically remove dirt and vacuum the coils. Place the refrigerator as far away as possible from heat sources such as stoves and radiators in order to keep the coils cool. Also leave a few inches of space between the coils and the wall to allow cooling air to circulate.
- Let hot food cool before storing it and the refrigerator will use less energy.
- Both the freezer and the refrigerator work more efficiently when relatively full. Items in the refrigerator should be spaced a little to allow air to circulate around them.
- Cover liquids. Uncovered liquids add humidity, making the refrigerator work longer.
- Invest in a refrigerator thermometer and keep the refrigerator at the proper temperature. The refrigerator compartment should be at 38° to 40° and the freezer at about 5°. For long-term storage in a separate freezer unit, the temperature should be 0°.

Energy Myth:

Turning on a light causes a "surge" of power, meaning it's better to leave a light on instead of turning it off when you know you will be using it again a short time later.

Fact:

A bulb that is on for one second uses one second's worth of electricity - no more, no less. This is true even for fluorescent bulbs - so turn lights off whenever they're serving no purpose.



Replace worn out refrigerator door gaskets.

Energy Myth:

Using hot water to flush grease down drains prevent clogging.

Fact:

Cold water helps solidify grease, preventing it from sticking to pipes. So save some hot water by using cold water to flush grease down drains and also through garbage disposals.

- Defrosting items slowly in the refrigerator will allow the frozen food to do some of the work electricity would normally perform.
- When you are gone for a long period of time, clean out the refrigerator, turn it off, and leave the door open to prevent mold.
- If you have a second refrigerator, keep it plugged-in only when necessary. Remember, it may cost about $150 a year to keep it operating. You may not want to pay that much just to keep the extra pop cold.

Cooking energy saving tips

Cooking fuel costs you about $50 to $100 a year. Here are a few common sense, free things you can do to shave a few dollars off this bill.

- Clean the shiny reflectors under the burners to better reflect the heat.
- Clean the gas burners occasionally. Food and grease can clog the gas ports. The flame should be even and blue.
- Adjust the flame so that the tip just reaches the bottom of the pan. The tip is the hottest part of the flame.
- Ceramic or glass baking dishes will cook foods at lower temperatures than metal pans.
- Sometimes you can't resist peaking in the over–just remember every time you do you lose 25° of heat.
- Turn off electric burners a few minutes before the food is done. The heat left in the burner will finish the cooking.
- When possible use the range top or smaller cooking appliances which use less energy than the over.

Automatic dishwasher tips

- Use the energy savings cycle if you have one.
- Allow dishes to air dry. You can save half the energy your dishwasher uses by not using the dry cycle.
- Use a cold rinse. (A high-quality dishwasher detergent will do more to prevent spots than either how water or a hot dry cycle.)

Laundry Room Energy Savings Tips

- Dry consecutive loads to use the heat left from the first load and make sure not to let the dryer run longer than needed to dry the clothes.
- Keep dryer filters and vents clean. Clean filters after every load–dirty vents and filters slow air flow and make the dryer use more energy.
- Use the lowest drying temperature possible.
- Don't vent the dryer indoors. You may gain a little heat (unwanted heat in the summer) but you are also dumping into your home a lot of lint and other pollutants as well as adding an undesirable amount of moisture to the air. Venting the dryer inside hurts much more than it helps.
- Wash in cold water using a cold water detergent. Use hot water only when absolutely necessary. Always rinse in cold water.
- Wash full loads, but don't overload. If you have an adjustable water setting, use it when washing small loads.

Summer Cooling Tips

- Close shades during the day to reduce solar heat gains. Outdoor shading devices such as awnings reduce heat gain through a window by as much as 90 percent while letting light in.
- If you're thinking of planting trees, consider putting them by a window on the sunny side of the house for natural heat-reducing shade. See our Energy Saving Landscaping Guide.
- Leave storm windows on windows that don't need to be opened, or on windows in air conditioned rooms. They help keep the heat outside.
- Use cross ventilation. Put a fan blowing in a window on the cool side of the house which will push out hot air while pulling cool air into the rest of the house.

Air conditioning

Air conditioning puts a tremendous strain on electrical generating facilities, not to mention your own checkbook so the best advice is to use other methods of keeping yourself and your house cool whenever possible. Here are a few tips to keep your air conditioner's energy consumption down when you do use it.

- Set the thermostat at 78° or higher–a reasonably comfortable and energy efficient indoor temperature. A 78° setting will save you about 15 percent or more on cooling costs over a 72° setting.
- Don't set the thermostat at a colder than normal setting. It will not cool the house any faster, but, as with the furnace, will simply overshoot the desired temperature and waste energy.
- Clean or replace filters at least once a month.
- Turn off the air conditioner when you are going to be gone for several hours and draw the shades to keep heat out. It takes less energy to re-cool the house when you return than it does to keep it cool while you are gone.
- Don't place lamps or other heat-generating devices near the thermostat since it could sense this heat and make the air conditioner run longer than needed.
- Room air conditioners should fit snuggly to window frames. Close heat ducts in the room and remove or seal up the unit with plastic after the cooling season.
- Have your central air conditioning unit checked and tuned when you have your furnace serviced.
- Periodically clean and vacuum the grills, coils and cooling fins and keep them clear of obstructions.

Energy Savings Tips for Your Car

Cars are a dominant source of energy use in American and perhaps the largest source of pollution. Maintaining your car so it lasts longer is of course a good idea, but many low/no cost steps also will reduce the money you spend on gasoline and will keep your car running cleaner and reduce harmful emissions into our environment. Here are a few examples.

- Regular tune-ups according to manufacturers' recommendations will increase gas mileage and reduce harmful emissions.
- Keep tires inflated to proper levels to increase gas mileage.
- Minimizing use of the air conditioner will increase gas mileage.
- Avoid opening windows at high speeds. It creates a drag and reduces gas mileage.
- Idling equals zero miles per gallon–avoid it when possible. If you can go inside a bank or restaurant instead of waiting to use the drive-through, do so.

Energy Myth:

When air conditioning, setting the thermostat at a very low temperature will cool the house faster.

Fact:

It only causes the air conditioner to run longer, not cooler or "faster". A low setting causes the air conditioner to overshoot the desired temperature and wastes energy.

HOME ENERGY GUIDE

TECHNIQUES TACTICS & TIPS

Attic Bypasses

Minnesota Department of Commerce Energy Information Center

Since the energy crisis first hit more than 20 years ago, millions of people have added insulation to their attics. Many were disappointed when their fuel bills didn't go down as much as expected—if they went down at all. Of course, one of the reasons for this is that energy prices kept going up. But there is another big reason: attic insulation bypasses.

Attic bypasses are hidden air passageways that lead from the heated space into the attic. Because warm air rises, it is continuously moving up these passageways and escaping into the attic during cold weather. (Figure 1) So even though the attic should be cold, attic bypasses make it a semi-heated space, which is a waste of energy.

These bypass leaks can cut the effectiveness of attic insulation by 30 to 70 percent. If you're expecting to save $300 a year from attic insulation, you could be saving only $90. The other $210 is lost because of these air leaks into the attic. Remember that fiberglass and cellulose insulation do not stop air from moving into the attic. They only filter and slow the air on its way out.

If you have many of these air leaks into your attic, adding insulation is not going to help much. Also, water vapor carried with the escaping warm air may condense, freeze and build up in the insulation. And when this water builds up, it can soak the insulation (wet insulation has almost no insulating value), cause plaster and paint to crack and peel, and lead to rot and other structural damage. When moisture problems appear in the attic after it has been insulated, attic bypasses are often the cause.

Ice build-up on the roof is another problem caused by attic bypasses. This build-up, called ice damming, happens when heat gets into the attic and melts the underside of the snow on the roof. The melted snow then flows down the roof, underneath the top layers of snow, until it reaches a cold spot such as the eaves, where it freezes, forming a dam, behind which more snowmelt and ice build up. The ice build-up can back up under the singles, damaging them, and allowing water to leak down to the ceilings and walls below. (Figure 2)

To avoid these types of water problems and to receive full benefit from your insulation, you need to plug up your attic bypasses. But before sealing them you have to find them. Most of the major bypasses are in the common areas described in this pamphlet. Other bypasses may also be found when you inspect your attic.

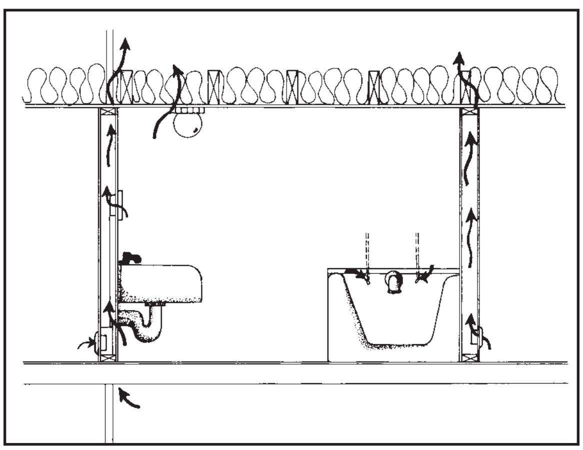


Figure 1
Warm air moves up hidden passageways, through cracks and leaks, then through the insulation into the attic.

Related Guides:
Basement Insulation
Home Insulation
Ice Dams
Home Moisture
Caulking & Weatherstripping

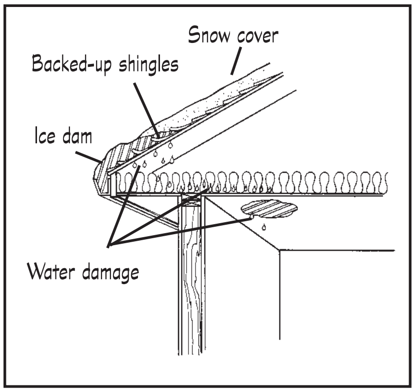


Figure 2

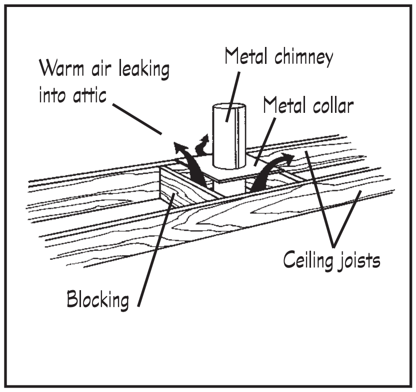


Figure 3

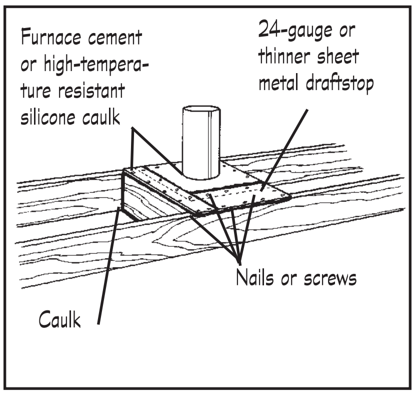


Figure 4

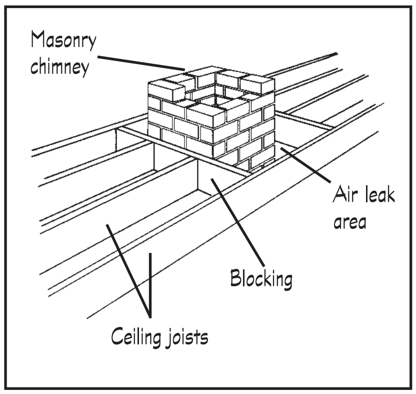


Figure 5

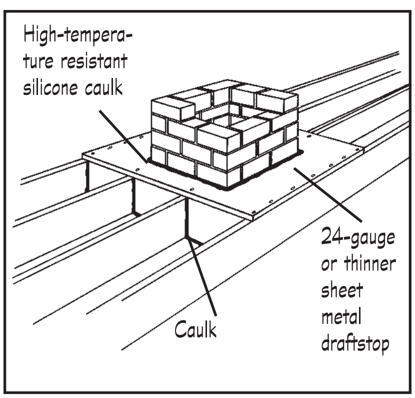


Figure 6

Looking for bypasses

Before getting into the attic to look for bypasses, make an accurate sketch of the room layout below the attic floor. The sketch should show the location of all the interior walls, switches and fixtures. This will make it much easier to find these problem spots once you enter the attic.

To look for bypasses, you may have to lift up your existing attic insulation and/or some floorboards. Signs to look for are wet insulation, dirty insulation, dust build-up underneath the insulation, water staining under the insulation, frost build-up on roofing nails, water staining on roof boards, and places below where you have had ice dam and moisture condensation problems. Finding any of these signs doesn't necessarily mean there is a bypass below, but they are good indicators.

Another way to look for bypasses is to go into the attic on a cold day and feel for warm air currents. Or use a lighted stick of incense or something else that smokes to check for air currents. Another thing to look for on cold days is patches of frost on top of the insulation.

Some common bypasses and how to fix them

This pamphlet presents brief descriptions of how to fix several of the most common bypasses. For more specific information, call the Minnesota Energy Information Center. One of the energy specialists can answer your specific bypass questions. The number in the Twin Cities area is 651-296-5175. Elsewhere in the state call 800-657-3710.

Chimney chaseway. For fire safety reasons, a clearance of two inches must be maintained between the chimney and any combustible materials, including the wood framing. But a draft stop can be built by cutting a piece of 24 gauge or thinner sheet metal to fit tightly to the chimney and the framing. (IMPORTANT: This is a draft stop only. Do not put insulation on top of it. Insulation must still be kept at least two inches away from the chimney.)

Newer homes usually have metal chimneys. (Figure 3) The chimney should have a metal collar where it penetrates the ceiling. As the illustration shows, the collar may be loose or may not cover the entire opening in the ceiling. To repair, add new sheet metal if necessary, and then use screws and a long-life, flexible caulk to seal the sheet metal to the framing. To seal the sheet metal to the chimney, use car muffler or furnace cement, or a silicone caulk that will withstand temperatures of up to 400 degrees F. Do not use other types of caulk. They may not withstand the temperatures next to the chimney. Also caulk the corners of the wood blocking so you have an airtight box below the sheet metal. (Figure 4)

Older houses often have an open gap between a brick chimney and the wood joints. (Figure 5) You can fix this opening in the same way as with a metal chimney. Cut the sheet metal into two halves to fit the chimney and then seal it in place in the same way as with a metal chimney. (Figure 6)

The Energy Information Center does not recommend using tightly packed fiberglass insulation to stop this bypass because it could come loose over time, and because the fiberglass could transfer too much heat to the framing, posing a possible fire hazard. Gypsum board should also not be used as a draft stop around the chimney because its paper backing poses a potential fire hazard. Stick with narrow gauge (thin) sheet metal.

Tops of interior walls. The tops of interior walls are easy to inspect if the attic is unfinished and uninsulated. Otherwise, you will have to pull up some floorboard and move the insulation. As mentioned before, a sketch of the room layout will help you find the tops of interior walls. In almost all older homes, the walls were built before the ceiling, so the area above the wall is not plastered. Figure 7a and 7b show air flow from gaps at the top of the wall. Flexible long-life caulk can be used to seal the smaller gaps and holes. (Figure 8) Larger gaps can be filled with expanding foam sealant, or sealed with strips of wood or rigid board insulation caulked or foamed in place.

A few older homes have completely open tops of walls. Wood, plywood, rigid board insulation, or gypsum board can be cut to fit over these openings and then caulked into place.

Plumbing and electrical penetrations. Electrical wires are often run up walls, into the attic, and then down to provide power to ceiling fixtures

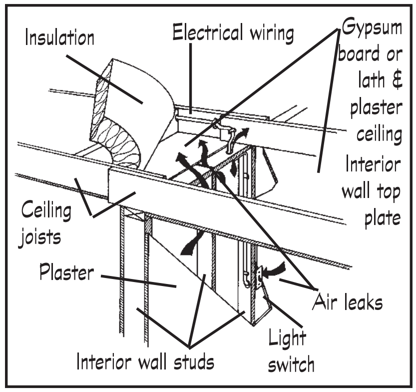


Figure 7a

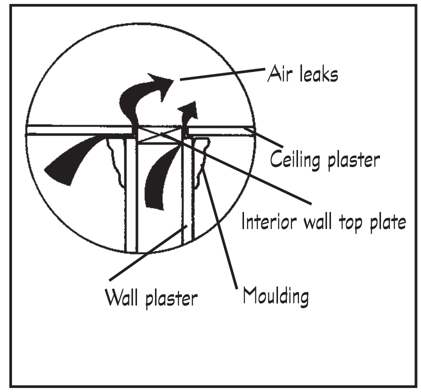


Figure 7b

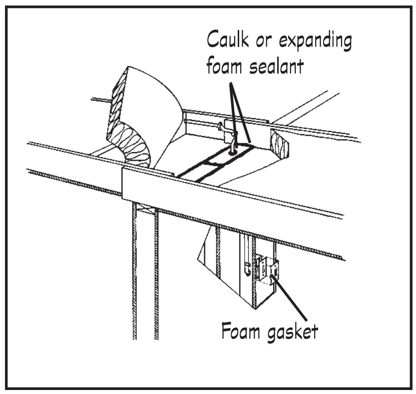


Figure 8

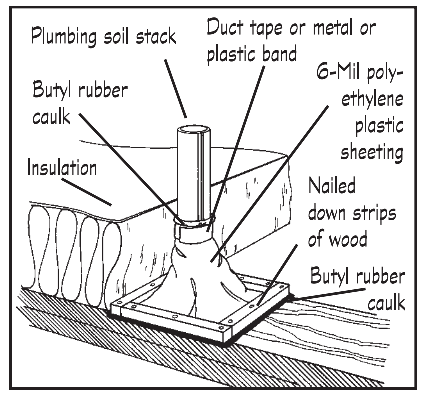


Figure 9

and electric outlets. These penetrations can most simply be sealed with expanding foam sealant where they enter the attic and where they leave the attic. With a ceiling light fixture, you need to seal the junction box above the fixture. This is covered in the section on lighting fixtures.

The most common plumbing penetration into attics is the soil or vent stack, the large pipe that runs from the drain plumbing through the roof. This is usually one of the major leaks into the attic and should receive priority. Special care needs to be taken in sealing this bypass. This is because wide temperature swings, plus wind pressure can cause the pipe to move in relation to the rest of the house. Therefore, you need to provide some flexibility to allow for this movement so that the seal will not be broken. To do this, use 6-mil polyethylene plastic sheeting to make a collar around the stack. (Figure 9) Gather the collar a couple of inches to accommodate the pipe's movement. Attach the bottom of the collar to the top of the plaster or framing with butyl rubber caulk

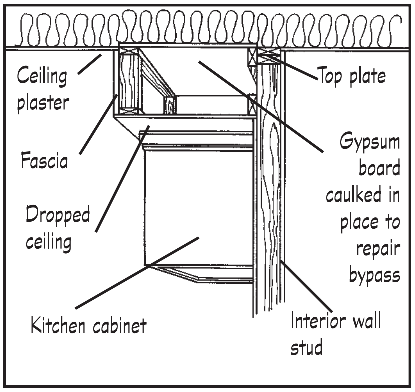


Figure 10

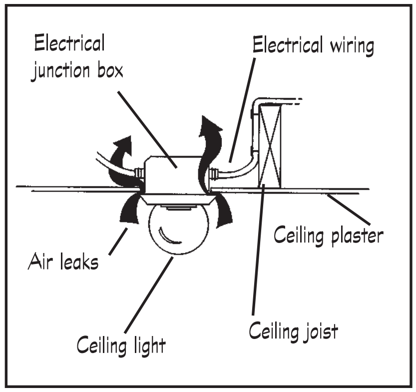


Figure 11

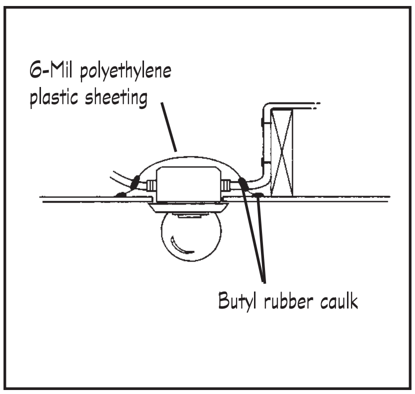


Figure 12

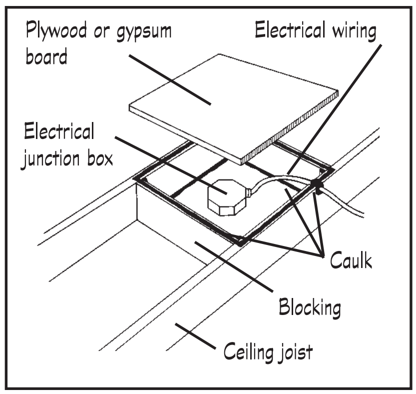


Figure 13

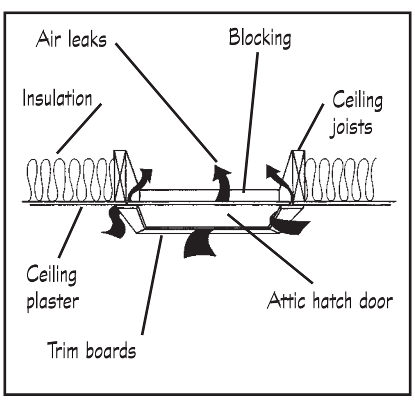


Figure 14

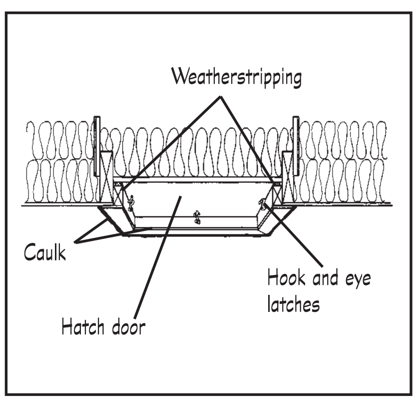


Figure 15

and secure it there with staples or strips of wood and nails. Attach the top of the collar to the soil stack with a good heavy bead of butyl rubber caulk and secure by wrapping duct tape or a metal or plastic band around the plastic and the soil stack. To seal the seam of the collar, lay on a good bead of butyl rubber caulk, fold over the seam a couple of times, and then use small spring binder clips (those black triangular paper clamps) to secure the seam.

In addition, you should wrap the soil stack in insulation all the way from the attic floor to the roof. This will prevent the moisture in the gases venting out of the stack from condensing and freezing in very cold weather, which could possibly block the vent and cause sewer gases to back up into the house.

Dropped ceilings. Kitchens, bathrooms and other areas of the home often have sections of ceiling that are lower than the ceiling in the rest of the house. These areas often are above kitchen cabinets, bathtubs and places like linen closets. One common type dropped ceiling is the slanted ceiling above stairwells. These dropped ceilings are an air leakage problem area because the house builder often did not continue the gypsum board or plaster to the top of the wall above the dropped ceiling. This allows warm air to move up the walls into the dropped area, and out the opening above the dropped ceiling.

To repair these air leaks, cut a piece of gypsum board to fit over the area above the dropped ceiling and nail and caulk it in place to the ceiling joists. (Figure 10) Do not use polyethylene plastic sheeting or other such material because it may not support the weight of the insulation placed on it for long periods of time.

Ceiling light fixtures. Before sealing these bypasses, check the wiring in the attic. Insulating over some older electrical cables might cause a heat build-up that will lead to deterioration of the cable wrapping and pose a fire hazard. If there is any noticeable deterioration, or if the wiring is very old (such as the old knob and tube wiring with two thick cables strung across porcelain insulators), you should have a qualified electrician replace it.

In a surface mounted fixture, the light bulb is below the ceiling. Since the fixture is not airtight, there is a bypass through and around the electrical wiring box above the fixture. (Figure 11) There are several ways to seal this bypass. The simplest, although most expensive and difficult to remove if you ever want to run another electrical line off that fixture, is to use a can of expandable spray form sealant and provide a thin cover over and around the box. Another method is to caulk all the seams and holes in the box. If the working surface is flat (i.e., a gypsum board ceiling), you can cut a piece of polytheylene plastic sheeting to cover the junction box, attach it to the ceiling with butyl rubber caulk and then secure it by tacking down small strips of wood to hold the seal in place. Cut small slits for the wires to pass through and then seal these holes with caulk and duct tape. (Figure 12) If the work surface is very uneven (i.e., some lath and plaster ceilings), it may be difficult to get a good seal at the ceiling level. In these cases, you can build a box around the electric fixture. (Figure 13) Cut wood blocking to fit between the ceiling joists to make the sides of the box. Notch the wood just enough to allow the electrical cables to come in. Then cut a top to the box out of plywood. Seal all the cracks and holes of the new box with flexible, long-life caulk.

If you are adding a new fixture, use a plastic junction box. It has fewer holes than a metal one does.

In a recessed light fixture, the bulb is above the ceiling in a metal box. Besides being a large air leak area, many types of recessed lights (especially older ones) can be a fire hazard in insulated ceilings. If covered with insulation, the light bulb heat can build up to a point where nearby combustible material may catch fire. As a result, the Energy Information Center recommends that recessed lights at the attic level be removed and replaced with either surface mounted fixtures or with new recessed light fixtures that are specifically rated for placement within insulation. If this is not feasible, it is sometimes possible to build an enclosure over the fixture and caulk this enclosure to the ceiling for an airtight seal. However, the size of the enclosure (it might have to be as big as nine cubic feet), and the amount of ventilation the fixture will require will depend on the size and type of fixture, and size and type of lamp, and the location of the light. You should not attempt building an enclosure over recessed lights

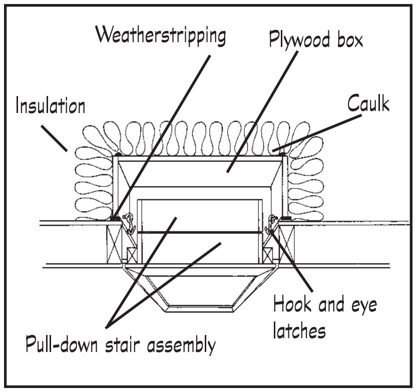


Figure 16

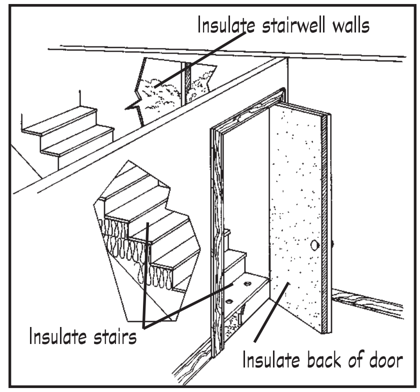


Figure 17

without first having them thoroughly checked by the electrical inspector in your jurisdiction. This is essential, because recessed lights in improper contact or close proximity to combustible materials can cause house fires.

CAUTION: Whenever you are working with lighting fixtures, be sure the electricity to them is shut off at the fuse box or circuit breaker.

Attic Entry. If your access to the attic is through a simple hatch, repairing this major bypass is easy. (Figure 14) To fix it, install weatherstripping to the edges of the opening where the door sets. Then install eye hooks to the underside of the hatch to pull the hatch down and compress the weatherstripping for a tight seal. (Figure 15) Also, caulk where the trim meets the ceiling. Don't forget to insulate the top of the hatch. Do it by cutting a piece of faced fiberglass batt to fit snugly within the blocking and staple the facing paper to the hatch door. Or you can glue rigid board insulation to the top of the door.

If the access to your attic is through a stairway or pull down stairs, sealing the bypass is more difficult. With pull down stairs, the best solution is to build an airtight plywood box that will fit over the stair assembly. (Figure 16) Caulk all the seams of the box and use weatherstripping and eye hooks to hold it tightly in place. You should then insulate over the box in the same way as described for hatch doors.

If there is a fixed stairway and the entry door is at

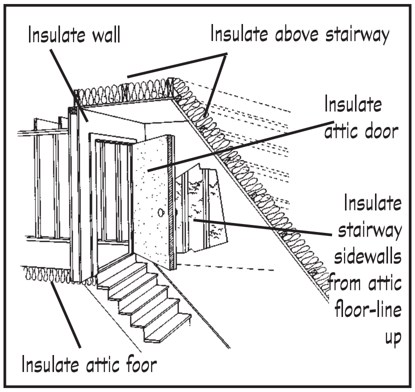


Figure 18

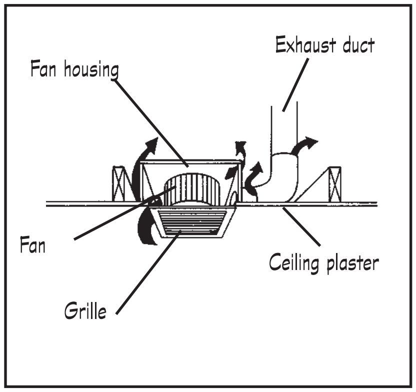


Figure 19

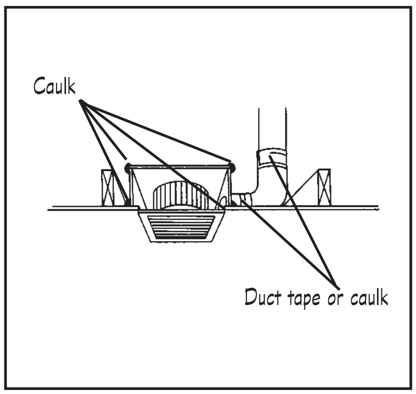


Figure 20

the bottom of the stairs, you have two basic options. One is to build a trap door at the top and seal and insulate it as you would an attic hatch. The second is to weatherstrip the existing door and attach insulation to the back of it. If you choose this second option, be sure the steps and walls are insulated and airtight. Then insulate the stairway walls and under the steps and risers. (Figure 17)

If the door is at the top of the stairway, insulate the back of the door, any wall space around the door, the stairway sidewalls (from the attic floor-line up) and above the stairwell. (Figure 18) Be sure to seal all cracks and weatherstrip.

Whole house cooling fans. A whole house cooling fan can provide comfort and energy savings in the summer, but needs to be sealed up in the winter to prevent it from being a major source of warm air leaks into the attic. To seal, build a box or cap the same way as described for pull down stairs and place it over the top of the fan.

Kitchen and bath exhaust fans. Kitchen and bath exhaust fans must be vented to the outside, not into the attic. If they are presently vented into the attic, you need to extend the ducting to the outside through the roof or soffit, or you are asking for water damage to the attic. Once you are sure your fans are properly vented, you can fix the bypasses around them.

Fan mounted to ceiling below attic: The metal box that encloses an exhaust fan is usually not airtight, and there is usually a gap between the box and ceiling. (Figure 19) To repair, use duct tape or caulk to seal gaps in the metal box and between joints and seams in the duct. Caulk the enclosure to the ceiling and framing. (Figure 20)

Exhaust fans should have a flap valve in the fan box as well as at the outdoor outlet of the duct, to prevent moist air from drifting up and freezing at the outlet. Check the valves in all exhaust fans and the clothes dryer. Dust, lint and grease build-up, or a sticking hinge, may prevent the valve from closing completely. Clean and adjust the valves to correct this problem.

Fan located on wall or non-attic ceiling: The point where the fan penetrates the wall or first floor ceiling should be sealed as well as possible to prevent warm air from filtering into the walls. If the exhaust fan ducting exists the warm living area of the house into the attic, seal the penetration with a rigid insulation board, plywood or gypsum board collar caulked into place. Be sure to seal any seams in the ducting with duct tape to prevent warm air from leaking into the attic.

With any ducting going through the attic, you need to insulate around the duct to prevent moisture freezing inside it and blocking it.

Knee walls. Many of the older houses in Minnesota are story-and-a-half houses, where the second floor is essentially a finished attic with slanting ceilings and knee walls–the short wall between the ceiling and the floor.

Knee wall construction often means major bypasses, leading to ineffective insulation and often leading to ice dams. These bypasses are a very important area to fix. Unfortunately, it is usually not an easy job.

Story-and-a-half houses are plagued by bypass problems because warm air moves through the second floor joist cavities–the open spaces between the first floor ceiling and the second floor flooring. (Figure 21) Because these open joist cavities extend beyond the knee wall, the warm air moves underneath the knee wall and reaches the cold space behind the knee wall. Besides being a big energy loss area, this situation often results in moisture condensation–leading to wet insulation, water damaged paint and plaster, and dry rot–and ice dams at the eaves.

There are a number of ways to approach this problem, depending on the characteristics of the house.

Situation 1. The area behind the knee wall is accessible through a door, and there is subflooring behind the wall. To address this area, you will have to cut and pull up the subflooring just behind the knee wall. Then cut pieces of gypsum board or rigid board insulation for blocking to fit snugly between the floor joists below the knee wall. (Figure 22a and 22b) Fit the blocking in place and then caulk all four edges for tight seal. The top edge is easier to caulk if the blocking is not pushed all the way under the knee wall. Then, if the area has not been insulated, you can blow in insulation under the floor boards in the area behind the knee walls. Be sure to weatherstrip and latch the access door so that warm air won't filter into the cold space.

Situation 2. There is no access to the area behind the knee wall. There are three ways to approach this problem. One is to remove the floorboards and subflooring on the interior (warm) side of the knee wall and install the blocking in the same way as described in situation 1. Before installing the blocking, insulate under the floorboards on the cold side of the knee wall.

The second way, which is preferable because you can insulate the back of the knee wall, is to cut an access through the knee wall and then fix the bypasses and insulate as described in situation 1. Then either install an access door or repair the wall after making the repairs and insulating. If you put in an access door, be sure to weatherstrip and insulate it.

The third way to get at the previously inaccessible area behind the knee wall is to come through the roof. This is a feasible alternative if you are putting in roof vents for attic ventilation, but

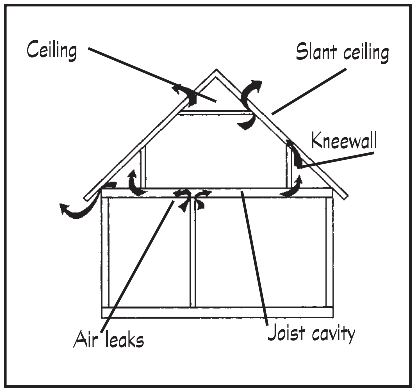


Figure 21

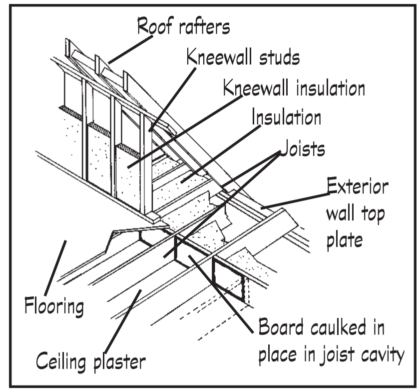


Figure 22a

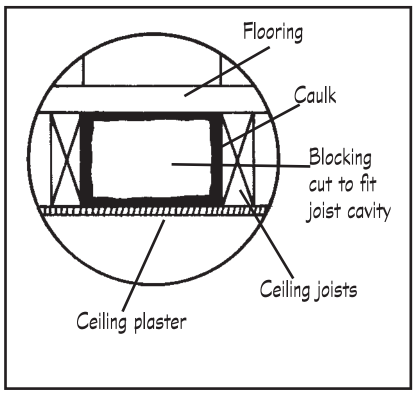


Figure 22b

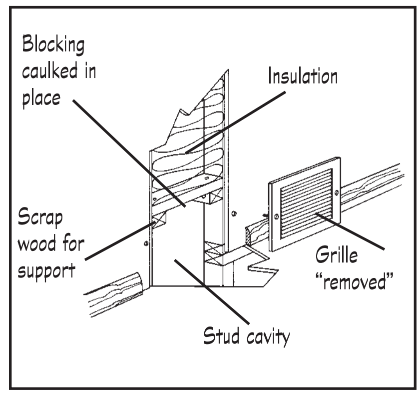


Figure 23

should be attempted by only very skilled do-it-yourselfers or professionals. After you have cut the hole for the vent to go in, there should be enough room for an average sized person to drop in and repair the bypasses as described in situation 1, and to insulate the area. Be sure you have a utility light with you, and someone there to help you.

Whenever you enter an inaccessible knee wall area to repair bypasses, be sure to also put in any insulation you want to add. For more information on this and on ventilating the attic with roof vents, see the Home Energy Guide on insulation.

Heating ducts. If you have heating ducts that go through the attic, seal around them where they enter and leave the ceiling level, and be sure to seal all the seams and joints with duct tape. For a longer lasting seal, you can caulk all the seams with a long life flexible caulk. You should also make sure they are well insulated (our Department recommends R-19), so that the warm air they are carrying doesn't cool off going through the cold attic.

Ceiling/exterior wall junction. Exterior walls are less of a bypass problem than interior walls if they are insulated. When exterior walls are filled with cellulose or loose, short-fiber fiberglass blown in at high pressure and density, air flow up the wall will be greatly reduced.

The rule of thumb with this area is to seal it wherever you can, but realize that in a lot of homes there are many areas that can't be reached without taking off roof boards. (If you plan to re-roof, it may be a good time to take off the first few roof boards and repair the bypasses from above.)

A common problem in this area is not being able to get enough insulation into the small area. This often causes cold spots and condensation, especially in corners near the ceiling. Whenever possible, cut pieces of high R-value rigid board insulation to fit, and caulk them into the top plate area. This will stop any air movement and improve the insulating value.

One area that needs special attention is the area above the cold air returns in exterior wall stud cavities. To solve this problem, remove the cold air return grill on the second floor (or first floor if a one-story house, or third floor if a three-story house). Then nail in some scrap 2x4 lumber into the studs so that you can put in a piece if gypsum board or wood cut to fit the stud cavity at a point just above the register. (Figure 23) Lay the cut piece of wood on top of the scrap lumber blocking and then caulk the perimeter. You can now blow in insulation into the stud cavity used as a cold air return at least down to the uppermost part of the air grill.

Other things you can do to prevent bypasses in this area are to seal any penetrations that may be coming up exterior walls, such as plumbing or electrical penetrations, and to fix any cracks in the ceiling/wall juncture inside the house. If there is wood molding at the ceiling/wall junction, caulk the top and bottom sides of it, and the cracks where trim pieces meet. Often when molding was used, the builders did not plaster or drywall behind where the molding goes, leaving a gap through which air could escape. Clear or color-matched caulks are available for areas like this where aesthetics are important.

Conclusion

If you have just read through this whole brochure, your reaction is probably, "What a lot of work!" Well, you're right. But it is extremely important to get your attic bypasses sealed if you want your insulation to really work well, and to protect your house from moisture damage. The bypasses presented in this guide are just the common ones. There are many more individualized situations that appear in the wide variety of houses in the state. It's more than likely that you have at least one problem that is not addressed here. But the basic principles of sealing bypasses should help you solve these problems. For more specific help, you can call the energy specialists in the Energy Information Center.

Fortunately, all of the materials required for fixing any of these bypasses are very inexpensive. Although it is work that requires a lot of attention to detail, it can be easily done by most homeowners.

HOME ENERGY GUIDE

TECHNIQUES TACTICS & TIPS

Ice Dams

Minnesota Department of Commerce Energy Information Center

Ice dams – or ice buildup on roof eaves – are all too obvious and all too familiar to Minnesota homeowners. The shelf of ice along the eave and the icicles are clearly visible, as are the dislodged roof shingles, sagging gutters, damaged insulation, and water stains on interior ceilings and walls that are the result of ice dams. What isn't clearly visible is what causes ice dams.

A major solution to ice dams is sealing attic bypasses . . . preferably during construction

Causes of Ice Dams

Although there are other causes (see sidebar), in most cases ice dams begin inside the house when heated air leaks up into the unheated attic. In the winter, the roof above the unheated attic is cold. When warm air leaks into the unheated attic, it creates warm areas on the roof which in turn cause the snow on the exterior of the roof to melt. The melting snow moves down the roof slope until it reaches the cold overhang, where it refreezes.

The process continues, causing ice to build up along the eaves and form a dam. Eventually this dam forces the water to back up under the shingles and sometimes into the ceiling or wall inside the home. In addition to the roof and water damage described above, ice dams may cause structural framing members to decay, metal fasteners to corrode, and mold and mildew to form in attics and on wall surfaces.

The Solution – Sealing Attic Bypasses

The pathways through which heated indoor air moves into the attic are called attic bypasses. To reduce ice dams, attic bypasses must be eliminated. Ideally, attic bypasses are eliminated – or prevented – when the home or building is constructed, since some attic bypasses are not always accessible after construction. The following areas are common sources of attic bypasses that are required to be sealed by the Minnesota Energy Code:

- penetrations in the building envelope for electrical and telecommunication equipment
- all exterior joints that may be a source of air intrusion
- lighting fixtures, including recessed lights and wire penetrations
- all plumbing and heating penetrations (including chimneys, flue pipes, and ducting)
- attic hatches
- balloon framed walls and walls that span both heated and unheated spaces, such as in split level houses
- dropped ceilings over bathtubs, closets and cabinets, and kitchen soffits
- other areas where walls are not completely sealed at the attic such as stairway walls and interior partition walls

Other common sources of attic bypasses not specifically covered by the code are:

- electrical boxes and fan housings (such as exhaust fans)
- kneewall construction in story-and-a-half houses

Related Guides:
Attic Bypasses
Combustion Air
Home Moisture
Home Insulation
Home Heating
House Diagnostics
New Homes
Indoor Ventilation

Combustion Air Caution

Any time a house is tightened to reduce air leaks, care must be taken to ensure that the furnace, water heater, fireplace, and any other fuel-burning appliance has sufficient combustion air to operate safely. For information on providing combustion air, call the Energy Information Center and ask for a free copy of the Combustion Air Home Energy Guide.

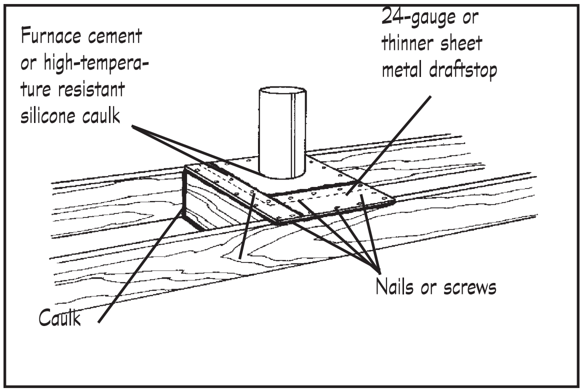


Figure 1
With a metal chimney, the ceiling penetration can be closed with sheet metal sealed with long-life flexible caulk to the framing. Silicone caulk resistant to 400 degrees F. should be used to seal the sheet metal to the chimney.

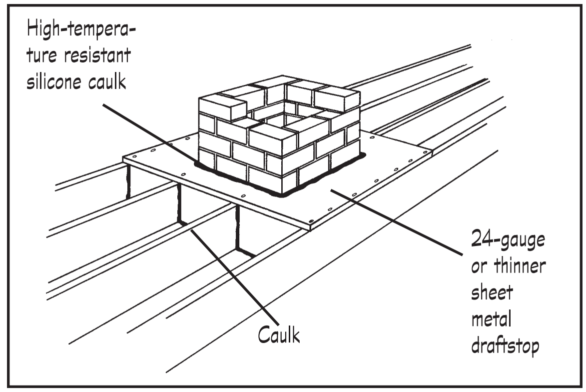


Figure 2
Gaps between a brick chimney and the joists can be closed with sheet metal cut into halves to fit around the chimney and sealed the same way as with a metal chimney.

Techniques for sealing various attic bypasses are illustrated above and on the next page.

Sealing Bypasses after Construction

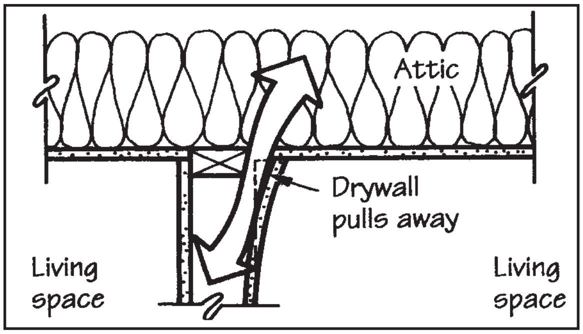
Homeowners guide. For the homeowner faced with an ice dam problem, not all of the techniques illustrated may be practical. The Home Energy Guide "Attic Bypasses" describes common sources of air leaks and methods the homeowner can use to seal them. For a free copy, call the Energy Information Center.

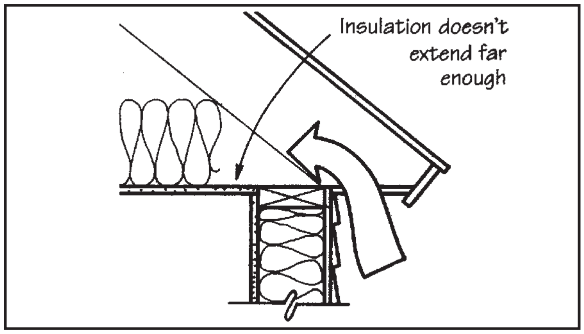
Diagnostic services. Both builders and homeowners may seek the help of technicians trained in using diagnostic equipment to identify sources of air leaks. A blower door test and an infrared scan can locate major leaks in houses and help determine whether they have been sealed effectively. Attic bypasses often follow long paths through building cavities before they enter the attic. For more information on pressure diagnostic testing equipment and a list of house doctors who provide these testing services, call the Energy Information Center.

Some Non-Solutions to Ice Dams

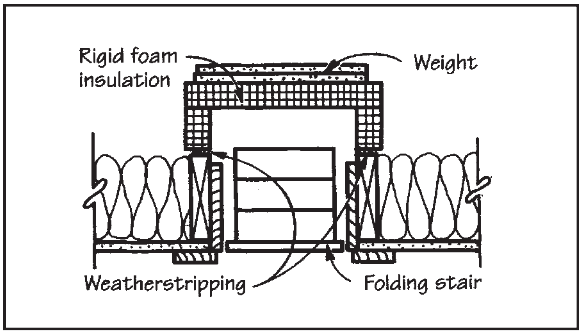
Increasing insulation and/or roof ventilation. Adding insulation helps reduce ice dams, but once you have reached an R-44 level, there may be little value in adding more insulation. Adding insulation without sealing attic bypasses could actually increase the amount of air leakage, diminishing the performance of the insulation.

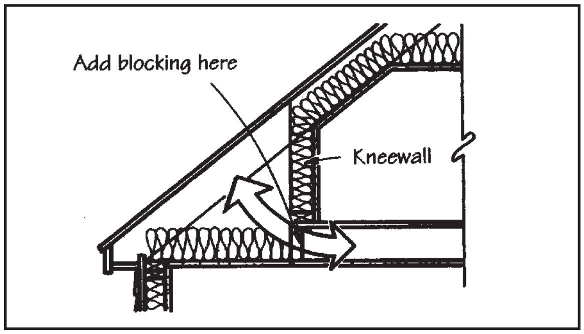
Roof vents are required by all building codes and should be installed according to building code standards. They are, however, only a partial solution to reducing ice dam formation. One caution: using power ventilators such as attic fans or other motorized devices can depressurize the attic, drawing warm moist air out of the house and into the attic.



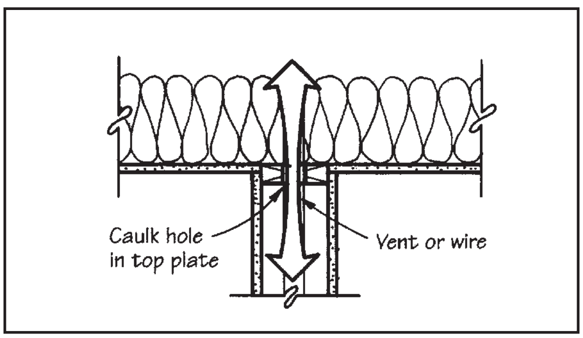


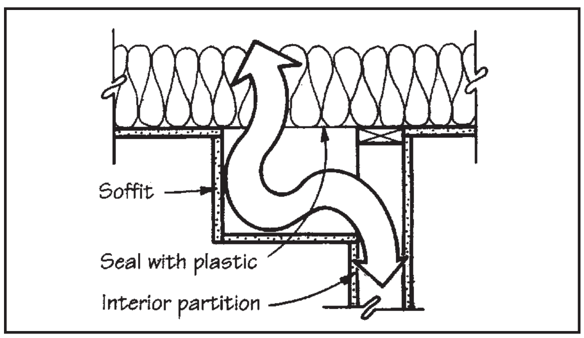
Above left: Leaks at wall-ceiling intersection. If the top plate shrinks and pulls away from the drywall, cold air will enter the partition and then the living space through openings such as electrical boxes. Prevent this by caulking the top plate or laying poly beneath the insulation batts in the ceiling. The same problem can also occur where a partition wall joins an exterior wall. Right: Cold wall-ceiling intersection at eaves may have mildew from condensation when insulation doesn't extend deeply enough into the eaves. Fix by extending batt far enough to completely cover the living space, but make sure to leave ventilation space below the roof sheathing.



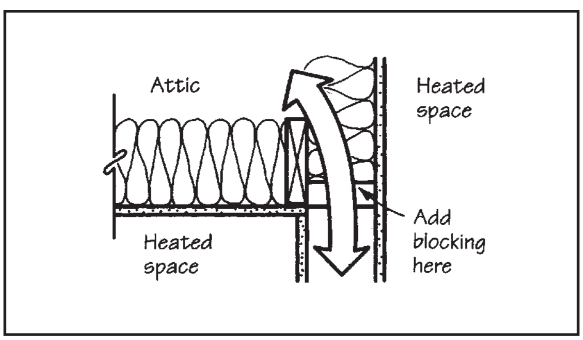


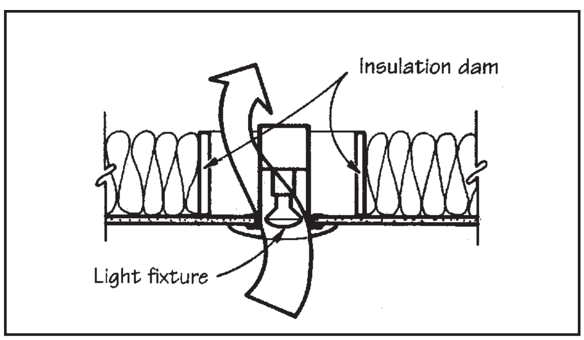
Above left: Attic bypasses occur when no seal or insulation is placed over the folding attic stair. The best solution is a box made of rigid foam with a little weight on top (wallboard works well), with weatherstripping to seal it. Right: A gap below the kneewall in the second story is a common area of air leaks. Unless the joist space is blocked below the kneewall, cold air enters the joist space. Block with rigid foam sealed with caulk.





Above left: Leaks around plumbing vents and wiring is a frequent problem. Fix by caulking or foaming around openings in the top plate or using rubber boots that slip around pipes or chases. Right: Unsealed kitchen or bath soffits are all too common. A soffit is hung from the framing with no wallboard at ceiling level to seal the insulation. Seal with plastic under the ceiling insulation. This may be hard to retrofit, but it's a major problem.





Above left: Unblocked stud bay to attic in split levels, similar to a problem in balloon framing, where stud bays continue past ceiling joists to the attic. Block with rigid foam. Right: Recessed ceiling lights are tough to deal with, though some models offer good air sealing. Reduce use of recessed cans as much as possible; look for fixtures designed and tested for low leakage.

Other Possible Causes of Ice Dams

The root cause of ice dams is a warm roof: a warm roof melts snow which trickles down to the roof edge where it refreezes and begins to form a ridge of ice. In most cases a warm roof is the result of attic bypasses (indoor warm air leaks up into the unheated attic).

Other factors can create a warm roof, however, including roof design. Roofs with large surface areas exposed to the sun and having small run-off areas are prone to ice buildup. A classic example is a roof with several gables or dormers. Very heavy snowfalls also can create problems: a foot or more of snow on a roof combined with warm winter temperatures can warm the roof and result in snow melt and ice on eaves. Leaking or disconnected heating ducts that pass through the attic also can result in a warm roof.

If you have ice buildup for any of these reasons, do not remove the ice by chopping since this could seriously damage the roof. Instead, use a side-walk snow melt product or have a roofer steam the snow off. If you replace a roof, install an ice and water membrane along the roof valleys and perimeter.

HOME ENERGY GUIDE

TECHNIQUES TACTICS & TIPS

Home Moisture

Minnesota Department of Commerce Energy Information Center

Complaints about excessive indoor moisture have become common in Minnesota as older homes are weatherized to reduce heating costs and new homes are built to better energy standards.

Standard building practices in the cheap fuel era produced extremely drafty houses. So much air leaked into and out of the living space that any moisture leaking into the house or created by cooking, bathing and other activities disappeared quickly.

But now, houses are being made tighter to keep the cold air out and the costly warm air in. One common unwanted result is too much indoor moisture.

Symptoms of excess moisture

Many signs of excess moisture are readily apparent; others are difficult to detect. One moisture symptom can have several causes, while one moisture source could be causing a large number of seemingly unrelated problems. There are a number of symptoms:

Odors. Odors increase in intensity with high relative humidity. Musty smells may signal mold, mildew or rot. Odors from everyday household activities that seem to linger too long may be a signal of too much moisture.

Frost and ice on cold surfaces; fogging windows. Frost or ice on any surface is a possible indication of trouble. Condensation on windows and other smooth surfaces can be a sign of excess moisture, or the need to stop air leaks, insulate, or warm the surface.

Another possibility is a faulty heating plant or other flame-fired appliance, which is causing excess moisture and combustion gases to enter the living space. Physical symptoms include frequent headaches, drowsiness, or other unexplainable illnesses. This possibility should be checked at once.

Damp feeling. The sensation of dampness is common in areas with high humidity.

Discoloration, staining, texture changes. These usually indicate some moisture damage, no matter what the material. These changes may appear as black or dark streaks or lines which border a discoloration. The area may or may not be wet.

Mold and mildew often seen as a discoloration, which may be white, orange, green brown or black. They are surface conditions that may indicate decay and are often noticed as a musty odor.

Water-carrying fungi look like a dirty white, or slightly yellow, fan with vine-like strands. The fungus can spread over moist or dry wood, and can be found under carpets, behind cupboards, on framing between subfloors or on damp concrete foundations.

Deformed wooden surfaces. Wood swells when it becomes wet, and warps, cups and cracks when allowed to dry.

Rot and decay. Wood rot and decay indicate advanced moisture damage. Unlike surface mold and mildew, wood decay fungi penetrate the wood and make it soft and weak. Look for any type of rot or mushroom-like growths. (See the sidebar on for more information on detecting wood decay.)

Related Guides:
Landscaping
Attic Bypasses
House Diagnostics
Windows & Doors
Caulking & Weatherstripping
Ice Dams
Indoor Ventilation
Basement Insulation
New Homes
Home Insulation

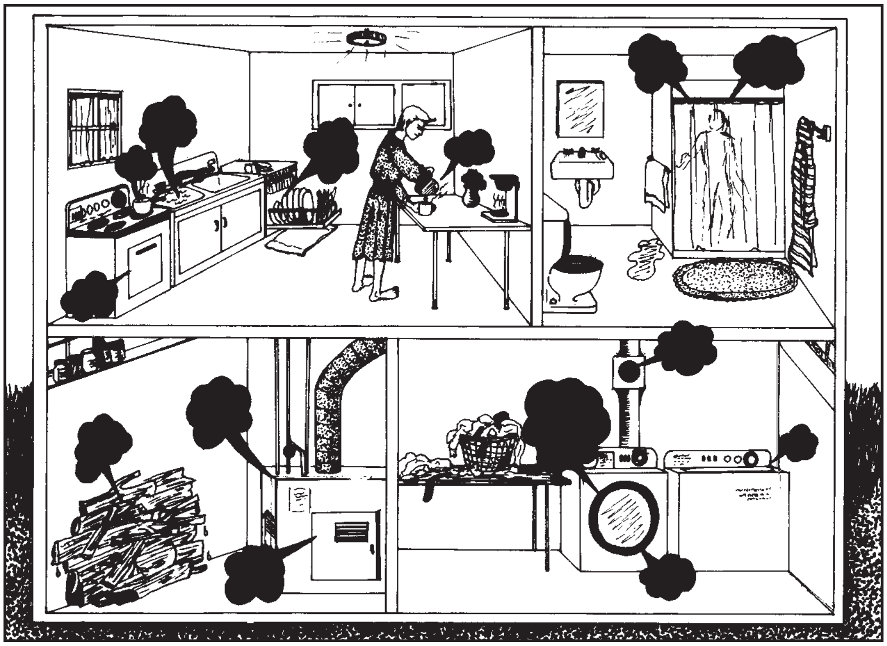


Figure 1
Common indoor moisture sources

Sweating pipes, water leaks and dripping. Water vapor may be condensing on cold pipes, or the pipes may be leaking.

Peeling, blistering, cracking paint. Moisture may be working from outside or inside the home to damage paint. Exposed surfaces between cracks or under blisters are a major signal of moisture-caused paint damage.

Crusty, powdery, chipping concrete and masonry. Concrete or masonry may show signs of deterioration after moisture has moved through it. Freeze thaw cycles speed the process of deterioration, causing chipping and crumbling. A buildup of salt or other powdery substance indicates that water was evaporated.

Indoor Causes

Many sources of excess moisture can lead to high indoor humidity and cause a wide variety of problems (Figure 1). Check each possible moisture source – the problems may have one or more causes – and take the corrective actions outlined in the Table Home Moisture Problems

New construction. Construction materials contain a large volume of water that is gradually released into the house as the materials dry. All new homes should have a mechanical ventilation system that provides a minimum of 0.35 air changes per hour to all rooms.

Basement floor and walls are often the source of excess moisture, particularly for homes in areas with high ground water and poor drainage. (see "Drainage Problems.".)

Inadequate interior ventilation. Poor ventilation of high moisture areas such as kitchens and baths commonly leads to damage. If the house has inadequate ventilation overall, moisture problems may be the first clue. Adequate ventilation will usually correct any moisture problems without further steps needed.

Attic moisture problems. Attic bypasses are areas where warm air escapes into you attic: around light fixtures, up walls, etc. Bypasses can allow enormous amounts of warm, moist air to leak into the attic. (Figure 2). Sealing them can save on winter heating expenses while preventing some moisture damage. Call the Energy Information Center and ask for the Home Energy Guide, "Attic Bypasses" for an in-depth discussion.

Too many occupants. People generate moisture. If there is less than 250 square feet of living space per person, there could be a problem.

Wood. Storing large amounts of wood in the house can lead to big problems. Though seemingly dry, wood can contain a great deal of water that will evaporate into the house as the wood dries.

Domestic activities. Cooking without lids, open-flame heating and cooking appliances, baths, showers, and hanging wet clothing and towels inside to dry can produce excessive moisture. Most low-volume shower heads save energy, but generate greater amount of water vapor. In addition, large numbers of house plants can produce a considerable amount of moisture.

Clothes dryer vented into the living space. Clothes dryers are sometimes exhausted into the living space to save the heat. This is a very bad idea for both gas and electric dryers. In addition to the moisture, significant air pollution may result from combustion by-products, lint, and residual detergent fabric softener and bleach products.

Temperature differences, lack of insulation. When warm, moist air hits a cold surface, condensation can sometimes cause water or frost damage and lead to the growth of mold or mildew. Rooms shut off from heating sources or used only intermittently, such as bedrooms or closets, are problem areas, as are areas made cold by drafts or spaces behind furniture on outside walls. Uninsulated walls and windows, and wall, ceiling or floor areas where insulation is missing or has shifted, such as the junction where wall meets ceiling, are other key locations (Figure 3).

Crawl spaces. In the summer, warm humid air can enter into crawl spaces and condense on cool surfaces. If the ground is not covered by an air-vapor barrier, large amounts of water vapor can escape into the crawl space. Eventually, this moisture may cause damage to wood and find its way into the living space. Missing air-vapor barriers are also a problem.

Missing, or poorly installed, air-vapor barriers. Air-vapor barriers–sometimes called air-vapor retarders–have been used for the last several decades. Air-vapor barriers do not stop all air or moisture movement. They only reduce the rate.

Tightly-built homes have a greater need for a durable air-vapor barrier that has been carefully installed on the warm side of the surface to stop moisture and air movement through building materials. If the air-vapor barrier is installed haphazardly, every point subject to air leakage is a place for condensation.

Air-vapor barriers should always be located on the warm side of the insulation (Figure 4). The cold side of the wall must be allowed to breathe, to allow any moisture that does not pass through to escape. An air-vapor barrier should be installed on basement walls, between the interior wall and the insulation.

Improper installation of air-vapor barriers is not uncommon. For example, if a building material that is, in fact, an air-vapor barrier has been installed on the cold side of the wall surface, moisture may be condensing in the walls. If an air-vapor barrier is used on two sides of a wall surface, moisture may build up without an avenue of escape.

Rigid insulation can be an exception to the warm-side, cold-side rule. Although it is still being studied, some researchers say that if the insulation is good enough (R-5 or more), the interior wall temperature will be raised and condensation should not occur under normal humidity levels.

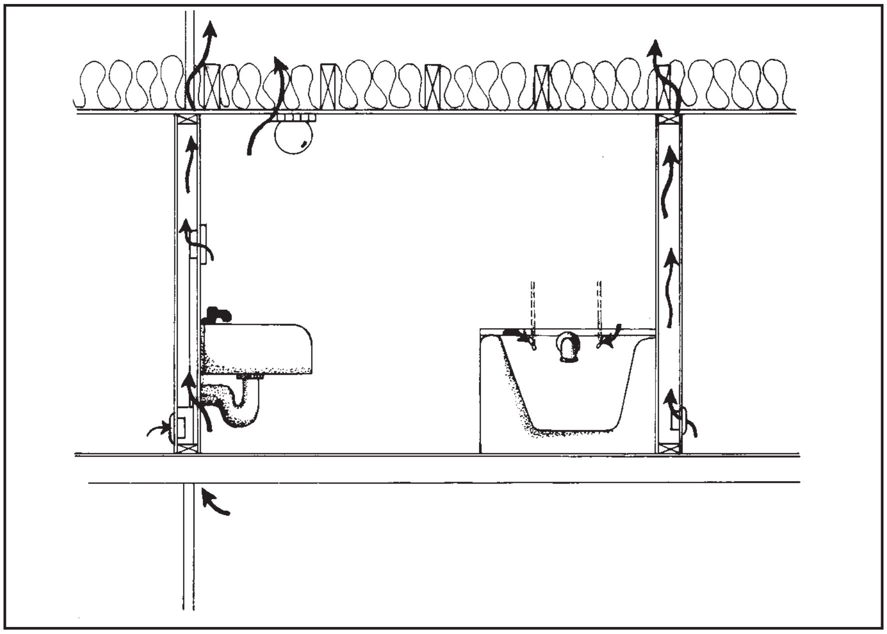


Figure 2
Attic bypasses from the bathroom.

Faulty heating plants. Faulty appliances used for heating, water heating or cooking can be sources of moisture problems. Without adequate combustion air, these appliances can spill water vapor and deadly carbon monoxide gas into the living area. Incomplete combustion is revealed by an excessively yellow or wavy flame and soot in the smoke, and can cause drowsiness, recurring headaches or even death.

Air conditioners, humidifiers. Used in a new or newly retrofitted house, humidifiers only add to construction moisture. Using a humidifier can also cause trouble after a house has been weatherized or tightened to reduce air leaks. In some cases, a humidifier can cause mold and mildew growth in leaky, dry houses. In general, a humidifier should not be necessary in a properly weatherized house.

Most air conditioners turn on and off by sensing temperature, not humidity. As a result, they do a better job of lowering the temperature than of dehumidifying. Over time, humidity can be raised, and if the indoor temperature has dropped enough, moisture can condense on interior sur-

Tip:

Ventilation is a major strategy to control moisture

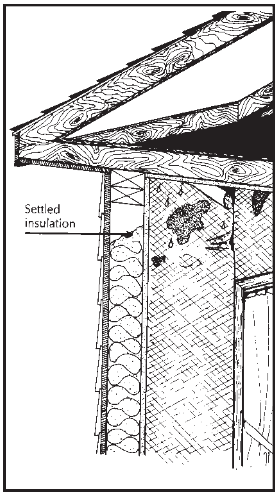


Figure 3

faces. Air conditioners that are too large for the space they are cooling can make the problem worse. Properly designed and sized conditioning systems should cause no problems.

Plumbing leaks. The best way to check the plumbing is to run each part of the system for 10-15 minutes while watching and listening for leaks. Check all accessible connections. Leaking pipes may be buried in a concrete slab floor or hidden in the walls.

Plants. Plants can generate large amounts of air-borne moisture. Attached greenhouses can cause moisture problems in the wall they share with the house because of condensation unless properly sealed with an air-vapor barrier. In addition, drainage may be a problem.

Outdoor causes

Poor drainage is the major exterior moisture problem. Proper drainage for foundations is critical. Construction details, such as flat ledges, inadequate drip edges, and bad flashing, can also cause problems.

Precipitation, humidity, soil moisture content, surface water, ground water table and outdoor water use can all change seasonally, creating problems that show only at certain times in the year.

Water in the ground may move through basement floors or walls and then evaporate into the air inside the house. If ground water is a suspect, use the capillary test (See Sidebar) to determine if moisture is wicking up through the ground or coming from the interior space.

High outdoor humidity. Consistently high outdoor humidity can cause a variety of problems, particularly higher cooling costs and constant mold, mildew and decay. Ventilating basements, crawl spaces and interior living spaces with high humidity outside air in the summer can aggravate existing moisture problems or cause new ones.

Blocked exterior air circulation. Foliage close to the dwelling or items stored next to the house, such as firewood, can block air circulation and cause localized areas of high humidity. Roof and soffit vents can become clogged by dust, leaves or tree flowers.

Ventilation

Ventilation is a major moisture control strategy. Passive ventilation is important for crawl spaces, attics and other unconditioned spaces, and mechanical ventilation is needed in kitchens, baths and sometimes other areas of the home. In new homes and extremely tight homes, mechanical whole-house ventilation is a necessity.

Indoor ventilation. The first preventative and corrective action with kitchens and bathrooms is to install fan venting systems that pull moisture out quickly. A minimum of 50 cubic feet per minute (cfm) ventilation in bathrooms and a minimum of 100 cfm in kitchens are recommended.

Ductless kitchen and bath recirculating units simply filter air, not remove it, and are not suitable for removing moisture.

If it is impossible to install the vents in the kitchen and bath, another option is to put an exhaust fan in a central location as close as possible to the humidity source and duct it to the outdoors.

For automatic control of unwanted moisture, any of these vent fans can be successfully connected to a dehumidistat that operates the fan automatically.

There are several methods of exhausting air from bathrooms and kitchens. Each has its strengths and weaknesses. *One rule must always be followed: always vent exhaust fans directly to the outside – do not dump the air into the attic or the soffit areas. Extensive damage can result when the moisture condenses on cold surfaces.*

Installing a fan in the ceiling and running exhaust tubing to a vent on the roof is common. Always seal all cracks and joints in the tubing and insulate it well. Also seal all cracks around the fan itself to reduce the amount of warm air that escapes through the bypass into the attic. Avoid venting a ceiling exhaust fan through the soffits.

In cold weather, roof exhausts will act like chimneys and send a constant stream of warm air out of the house. The roof vents are another potential place for leakage and can become blocked with snow and ice. The stream of warm air can melt the snow on the roof and cause ice dams. If the exhaust pipe is not well insulated, water vapor can condense on the walls of the pipe and leak back down into the living space.

Running the exhaust pipe down an inside wall and venting the air out through the rim joist works well, but can be difficult to do in existing houses. The fan can be placed at the bottom of the duct and can be quieter than a ceiling unit. Running the exhaust duct down and out also eliminates the chimney effect of a ceiling and attic system (Figure 5).

In kitchen fan systems, use a replaceable or washable filter element that will keep grease from accumulating in the duct work. Clean the filter often.

An occasionally-seen tactic for bathrooms is a to install an overhead infrared heat lamp. These lamps are sometimes combined with a blower to help circulate the warm air. The heat lamps only reduce visible signs of condensation and increase comfort – they do not remove moisture. An exhaust fan is a better solution.

Wall exhaust fans are also available. In general, the wall fan will lose a great deal of energy and cause drafts. It may also become frosted over during cost weather and cause moisture stains on walls when the frost melts.

Attics. Ventilation and eliminating attic insulation bypasses are the main strategies to avoid moisture problems in attics.

Seal around all penetrations into the attic, such as plumbing pipes, chimney chaseway and electrical wiring. Call the Energy Information Center and ask for the Home Energy Guide, "Attic Bypasses," for complete information.

Attics should be ventilated with passive vents that are located to promote good air circulation. Half of the vents should be placed high on the roof, at least three feet higher than the lower vents, which should be as close to the eave as possible (Figure 6). Using a fan for attic ventilation is costly and can draw moisture and heated air into the attic.

The size of the vents depends on four factors: total area to be vented, type of vent opening (screens or louvers), vent location and whether an air-vapor barrier is present.

The general rule is to provide a vent-to-space ratio of 1:300; that is, one square-foot of attic ventilation area is needed for every 300 square feet of space to be vented if a vapor barrier is in place and half of the vent area is located at least three feet above the eave vents. If roof vents are less than three feet above eave vents and there is no vapor barrier, the ratio is 1:150 – one square foot of vent area for each 150 square feet of attic area.

When adding insulation to the attic, take care to keep all vents open. Rigid vent troughs can be installed on the underside of the roof sheathing to

Combustion air caution

Exhausting moist air out of the house with the aid of exhaust fans helps solve home moisture problems. It is important to remember, however, that exhaust fans and clothes dryers reduce the amount of air available for combustion by furnaces, water heaters, and other fuel-burning appliances. A shortage of air for these appliances can result in backdrafting of dangerous gases into the home. To prevent backdrafting caused by a deficiency of air, install a ventilation system that brings fresh air into the home to compensate for the air exhausted out. Another option is to buy "sealed combustion" type appliances, which bring outside air directly to the appliance.

Figure 4
Air-vapor barrier placement

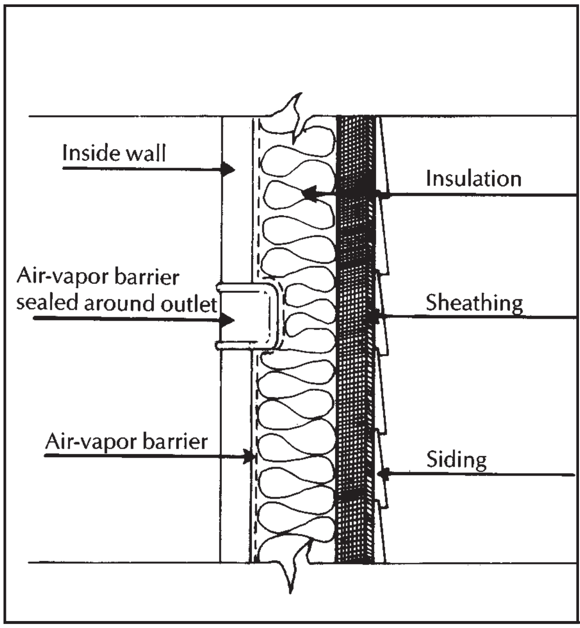
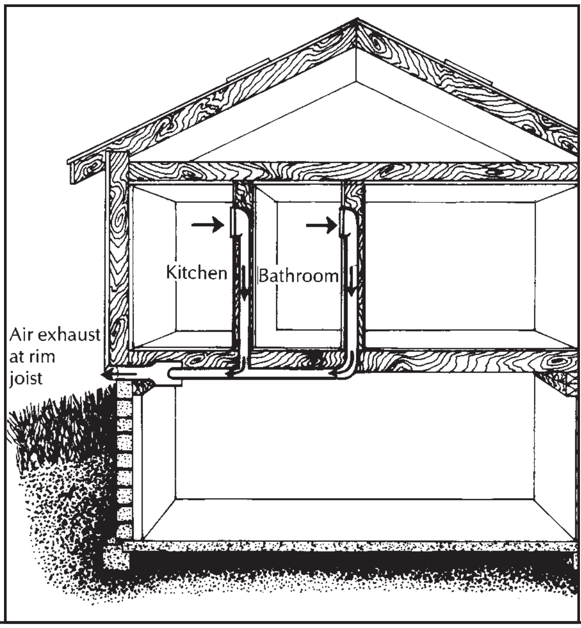


Figure 5
Mechanical ventilation



Tip:

To solve drainage problems, focus first on exterior solutions

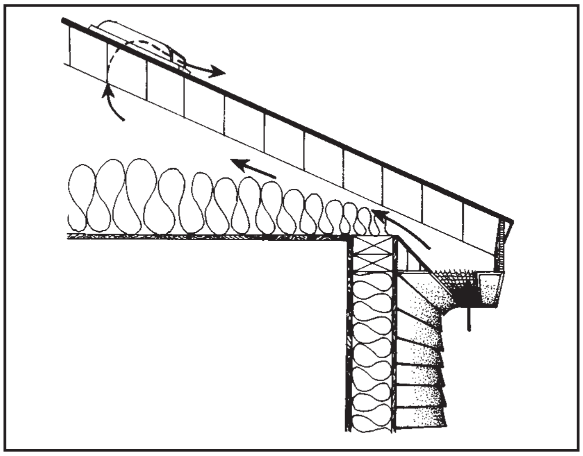


Figure 6

prevent thicker levels of insulation from blocking airflow.

Unfaced insulation is best. If you are installing kraft-backed insulation, the backing can act as an unwanted air-vapor barrier on the cold side of the insulation. Moisture can become trapped behind it, reduce the insulating ability of the insulation, and possibly cause ceiling moisture damage. Cut the backing to allow moisture damage. Cut the backing to allow moisture to escape from the insulation and be carried out of the attic by passive ventilation.

Basements. During warm, humid weather, ventilation with outdoor air can cause condensation in basements and make the indoor moisture problem worse. If the floor or walls are sweating, close basement windows and doors to keep out the humid air. Use a large fan to circulate the air in the basement. If may be necessary to use a dehumidifier to keep the basement dry during the humid months.

Another mechanical method of ventilation is the air-to-air heat exchanger. The air-to-air heat exchanger serves as a heat recovery ventilation system; it extracts heat from outgoing stale air and uses it to warm the fresh, cold air coming into the house. Heat exchangers also need defrosting in very cold climates, and some exchangers have an automatic defrost cycle.

Crawl spaces. The air-vapor barrier is usually a tough, puncture-resistant material (often 6 mil polyethylene) laid over the soil and held in place with weights or bricks. For best protection, overlap the sheets of polyethylene and seal together with contractors' sheathing tape designed to adhere to plastic sheeting. Seal the edges to the walls (Figure 7). Do not use caulk to seal the plastic to polystyrene insulation as caulk may react chemically with the insulation and not adhere to the poly film.

As with basements, ventilation of crawl spaces may cause sweating of concrete or masonry walls below grade because these surfaces stay at a cooler temperature and outdoor air may hold enough moisture to cause condensation. Beyond the routine action of installing a ground cover air-vapor barrier in the drawl space, other actions may be needed to avoid causing this problem.

Drainage problems

Common sources of drainage problems include excess surface and ground water, and clay soils. When combined with poor construction details, drainage problems can quickly cause moisture damage, from roof to basement.

Some drainage improvements are fairly simple, such as adding down spouts and replacing flashing. Others are costly or require a lot of labor for retrofit applications, such as excavating around the basement walls to get at the source of a severe ground water problem.

In some cases, more radical action may be needed, including efforts that are traditionally used to control excess high water tables. These actions include adding drain tile systems, sump pumps, dry wells, floor drains, and laying a new basement floor over a waterproofing layer.

It is best to first tackle the water problem from the outside. Most interior efforts treat the symptoms of the problem, not the causes. In some cases, extensive interior retrofit action, such as a drain tile system below the basement floor, is the only available route, but it may not produce satisfactory results in severe situations. The wall may become saturated with water.

Even in systems where the foundation is tied into the drain tile system, the block wall may still be wet enough to allow a significant amount of moisture to migrate up into the frame walls.

Exterior solutions. Adding soil around the foundation to achieve a good slope away from the house is a basic treatment. A 6-inch slope over a 5-foot run is recommended. Where cost or lack of space prohibit meeting the recommended slope, slope the soil as much as possible, and try to channel water away (Figure 8).

Use rain gutters on the roof eaves with long extension spots to channel water away from the house. Ground level drains can also be installed at the drip line. Inspect and repair flashing details all around the house.

In new construction and comprehensive retrofits, another basic preventative measure is to install a sloped drain pipe along the footings with use of gravely soil next to the foundation.

If the problem is severe, waterproofing the basement or foundation walls and slab floors is recommended. Waterproofing stops the direct flow of water, and it often consists of several layers of membranes

Waterproof material – at least the equivalent protection of two-ply hot mopped felts, 6-mil polyvinyl or 55 pound rolled roofing – should be carefully applied and sealed at all seams. Waterproofing should extend from the edge of footings to the finished soil line. Waterproof material should also be placed under basement and ground slabs, but in practice this can be very difficult to do.

Heavy rains may cause seasonal back-up of storm sewers, and if soil is heavy, it may retain water for long periods of time even though high ground water isn't a normal problem.

In general, if the soil type is sandy and gravely, and ground water is below the foundation level, drain tiles at the footings are unnecessary because the soil's natural drainage will be adequate. However, seasonal changes and terrain may require some exterior waterproofing, and may make installation of drain tile worthwhile.

Remember that when exterior waterproofing is required, a backfill of crushed gravel should be considered, especially for areas with clay soil.

Interior solutions. Remember that most interior water-stopping action deals with the symptoms of the problem more than the cause. Attempts can be made at controlling the moisture problem with the use of wall coatings, drainage and sump pumps.

Insulating walls

Insulating the walls of older homes usually means blowing in cellulose or similar loose insulation. It is unusual to need an air-vapor barrier in those situations. Condensation problems are rare, and usually localized in an area of high moisture generation, such as the bathroom, and where there is too much air leakage, such as around leaky electrical outlets.

The Energy Information Center recommends using ventilation in those areas and sealing any penetrations into the walls, such as around electrical outlets and switches, with appropriate gaskets. Built-in cabinets, windows, doors and baseboards are other potential areas of condensation because of air leakage.

If the interior wall surfaces are to be removed as part of a remodeling or renovation effort, a 6-mil or thicker air-vapor barrier can be easily installed at that time. Mechanical ventilation and sealing of all penetrations are still recommended.

Water vapor moves into wall cavities both by air movement and diffusion, but air movement is by far the more powerful force. Seal penetrations around windows, doors, where the wall meets the ceiling and floor, and any cracks or holes in wall surfaces.

Windows

A good rule of thumb with older windows is to always tighten the existing prime window first with weather stripping and caulk. If an outer storm window is being added, make sure it has small weep holes at the bottom to allow moisture to escape – exterior storm windows should not be made airtight.

With interior storm windows, make sure that the seal is tight around all edges. The tighter the seal, the less condensation on the prime window.

Capillary test

To determine if moisture is coming through the foundation walls or floor to the inside, or whether moisture is coming from inside the dwelling itself, do the following:

1. Identify the damp interior surface. Testing of multiple locations on the floor or walls may be necessary to locate external sources of moisture.
2. Dry a portion of the damp area approximately 2 feet by 2 feet. (A hair dryer can be used.)
3. Cover the dried area with an air-vapor barrier, preferably polyethylene, firmly attached and sealed with tape around the edges.
4. Check the underside of the air-vapor barrier after a couple of days. If there are beads of moisture under the barrier, there is water seeping or wicking through the surface into the dwelling.

However, if the air-vapor barrier is wet on the room side and dry underneath, the dampness is from another source of moisture. It is possible for both sides to be damp, which indicates both external seepage and internal condensation problems.

This test is sometimes difficult to interpret. Seasonal variations in surface water flow patterns and the ground water table can cause confusion. You may need professional advice.

Home moisture problems

- **Inadequate interior ventilation.**
  Install externally venting fans in kitchens and baths. For localized moisture problems in the home, especially unstoppable condensation, try aiming a small fan at the area to circulate warm air. Provide circulation and ventilation inside the home by opening windows, considering cross-ventilation, and similar strategies. If a significant amount of ventilation is needed, a central exhaust fan or air-to-air heat exchanger could also be considered.

- **Inadequate attic or crawl space ventilation.**
  Install any needed vents in attics, crawl spaces and other areas. Check insulation to see if it is blocking ventilation routes. Seal attic bypasses.

- **Too many occupants; building too small.**
  Step up ventilation. Try to reduce interior moisture sources.

- **Wood.**
  Do not store more than a few days supply of wood in the house.

- **Too many internal sources from domestic activities.**
  Use existing exhaust equipment in kitchens and bathrooms. Install fans if they are not present. Become aware of moisture-generating activity and reduce moisture production. Step up overall ventilation, if necessary, by opening windows, using whole-house or local exhaust fans. Consider installing an air-to-air heat exchanger if appropriate.

- **Clothes dryer vented into the living space.**
  A very bad idea. While there is a small heat gain, there is also a large amount of moisture and other airborne pollutants. Don't do it.

- **Cold surfaces; lack of insulation.**
  Seal the infiltration leaks first, then insulate, employing proper air-vapor barrier techniques. Check existing insulation. Insulate windows with additional glazing or other treatments that seal around all edges. If insulation is impossible, continuous circulation of air with a fan in the problem area will help reduce condensation. For closets or other out-of-the-way places, leave doors open or install louvered doors for better air and heat circulation.

- **Missing or poorly installed air-vapor barrier.**
  Inspect materials on the cold side of the home to determine whether a sheathing or siding may be acting as an unwanted air-vapor barrier. Search for places where the air-vapor barrier may not have been installed, such as the rim joists. Install air-vapor barriers where needed.

- **New construction, retrofit, remodeling.**
  Install mechanical ventilation to provide 0.35 air changes per hour.

- **Unvented heaters, faulty heating plants.**
  Check for blocked furnace vents, a chimney blockage, a chimney that is too short, insufficient combustion air or whether the system is vented at all—do not use an unvented kerosene or gas heater. Make sure your home has an adequate supply of combustion air - call the Energy Information Center and ask for the Home Energy Guide, "Combustion Air." If you suspect the heating plant is faulty in any way, call for help from the local utility or a heating contractor. Don't wait.

- **Air conditioners, humidifiers.**
  Use humidifiers only when needed. Otherwise, avoid them. An unnecessary central humidification system can be disconnected. The main overall action for air conditioners is to keep the thermostat setting at 75°F or above, to help save cooling dollars and to keep surface temperatures above the point at which condensation will occur. Drain air conditioning condensation to the sewer system or the outdoors, not the crawl space.

- **Plumbing leaks.**
  The best way to check the plumbing is to run each part of the system for 10-15 minutes while watching and listening for leaks. Check all accessible connections. Leaking pipes may be buried in a concrete slab floor or hidden in the house.

- **Plants, attached greenhouses.**
  Provide adequate air circulation and ventilation. Avoid excessive watering. Keep the greenhouse at recommended humidity levels. If the humidity is high, avoid venting into the home. Provide proper exterior drainage away from the house and the greenhouse. Use proper air-vapor barrier and insulation techniques.

- **Long-term air conditioning.**
  Periodically, turn off the air conditioner and ventilate the house when the outside humidity is low.

- **Drainage around house.**
  Slope the ground around the foundation so that water will drain away from the house. Check for blocked downspouts and gutters. Install rain gutters where necessary. Check for cracks in foundations, and install proper perimeter footing drains, if necessary.

- **Ground water.**
  Add an air-vapor barrier and ventilate the crawl space. Fix basement drainage with drain tiles, drain pipe or sump pump. Try fixing cracks in the foundation and use foundation waterproofing. In new construction, lay down a moisture barrier before pouring concrete slab floors.

- **Blocked exterior air circulation.**
  Cut back foliage to allow for circulation. Move stored items away from the house to avoid reducing circulation. Keep vents clean.

Some condensation and light frost on an exterior storm window can be normal. However, if the buildup is heavy and remains on the storm window for an extended period, it can be a sign the prime window should be sealed, or the indoor humidity is too high, or both.

Newer interior window insulation products, such as the popular shrink plastic kits, provide a tight seal around all edges to avoid condensation problems. They add another insulating layer of glazing to the window and are very effective at reducing or eliminating condensation problems on the inside of windows.

They are also very effective in reducing air leakage. Although reduction in air leakage is desirable, a caution should be noted: if steps are not taken to reduce home moisture levels, using these window products may result in moisture problems moving to other, less visible locations.

Traditional drapery and blinds can aggravate window condensation because the window surface gets colder, heat circulation is impeded and the window covering doesn't provide for a tight seal.

A special and hard-to-spot problem can occur with double-hung windows. Warm, moist air can enter the cavities through holes where the pulley-sash cord is located or from the sides of the interior window trim and condense on the cold counterweights. Frost and ice can build up on these weights, and when the ice melts, it can leak into the wall cavity.

Two solutions: either caulk around the interior window trim where it meets the wall and seal the pulley holes, using a sealing device that allows the cords to operate; or remove the weights, seal the cavities, and seal the pulley openings. To keep the window operable with the second option, install low-cost sprint clips. (Note that these clips may not work on extra large windows).

See the Energy Information Center guides "Windows and Doors" and "Caulking and Weatherstripping" for details.

Detecting air leaks

House doctors specialize in home energy use and can help locate air leaks. Among the diagnostic tools they use is the blower door test. Using a fan, a frame-and-panel assembly that fits into an exterior door opening, and some instrumentation, a blower door test tells how tight a house is and helps pinpoint air leaks. Call the Energy Information Center for a list of house doctors.

Window condensation: causes & cures

Condensation is not necessarily an indication that your windows are bad and need to be replaced. Condensation will occur whenever the window surface is cool enough to allow moisture in the air to condense on it, which is why some condensation can be expected in the winter. Condensation should be controlled as much as possible, however, since it can damage the window's components. For instance, moisture on the inside of the storm window indicates that the prime window is allowing air (carrying moisture) to leak out to the storm window where it condenses. Stopping these air leaks with caulking and weatherstripping will stop the condensation and ultimately save your windows. However, it is important to understand that condensation on windows can occur for a number of reasons. Before you replace your windows, call the Energy Information Center for advice.

When window condensation will occur

Outdoor temperature (°F)	30°	20°	10°	0°	-10°
		(Average indoor humidity = 30 to 35%)			
Indoor humidity (%) at which condensation occurs:					
*Insulated glass – double					
Center of glass	57%	50%	44%	39%	35%
Edge of glass	47%	39%	33%	22%	17%
*Insulated glass – double, low-e w/argon					
Center of glass	74%	70%	65%	61%	57%
Edge of glass	50%	43%	36%	30%	26%

(*Assumptions: wood frame, aluminum spacer, 3/8" air space, emissivity of .08)

(From: Patrick Huelman and Timothy Larson, "Performance of Window Systems in Cold Climates;" Building Solutions 1993 EEBA/NESEA Conference, Vol. 1; Energy Efficient Building Association, Minneapolis, MN, 1993)

Wood Deterioration

Decayed wood is more permeable to moisture and more subject to further damage and decay. Recognizing wood decay is a skill that comes with practice, but several symptoms stand out.

White rot is probably the worst form of wood decay, and often it is the most difficult to recognize. Wood infected with white rot appears somewhat whiter than normal, sometimes with dark lines bordering the light discoloration. Because the wood doesn't visibly shrink or collapse, people sometimes miss the fact that wood with white rot is seriously weakened and possibly ready to collapse. In advanced stages, some cracking across the grain occurs with white rot.

In contrast, **brown rot** readily shows as a brown color or brown streaks on the face or end grains. In advanced stages, the wood appears damaged, with cracks across the grain, and the surface shrinking and collapsing. Both white and brown rot are serious forms of wood decay that deserve treatment and/or wood replacement.

Soft rot and **blue stain** are less damaging forms of wood decay that tend to be more active on the surface. Soft rot is recognizable because the wood surface appears soft and profusely cracked, resembling driftwood in color. The soft rot decay is slower acting than white or brown rot. Blue stain indicates somewhat weakened wood, with a blue, brownish black, or steel-gray colored staining. The discoloration actually penetrates the wood cells and is not a surface stain.

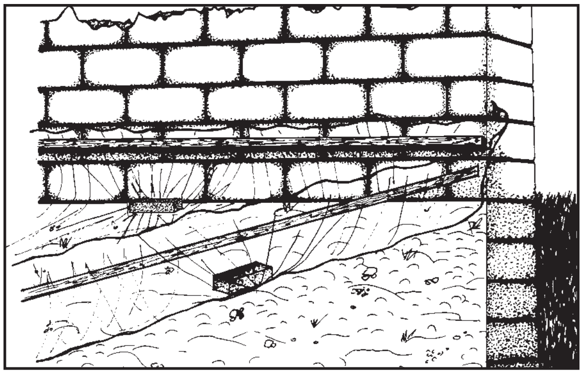


Figure 7
Crawl space air-vapor barrier

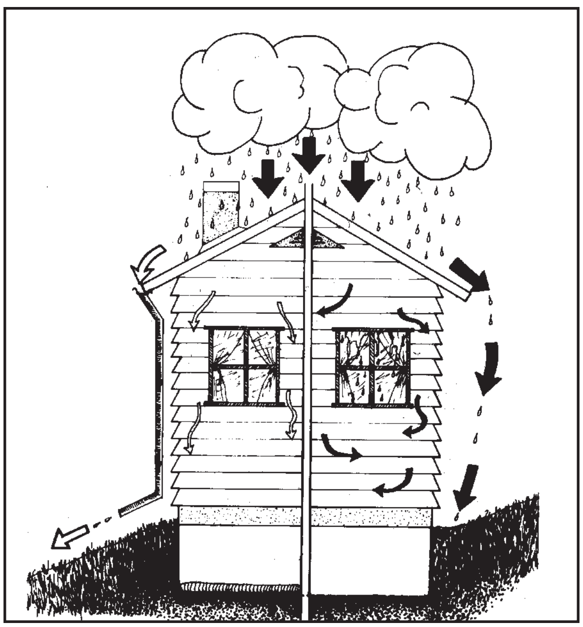


Figure 8
Gutters, a slope away from the house and drainage tile in the foundation keep the left side of this house dry. No gutters, a slope toward the house, and no drainage tile expose the right side to moisture damage.

Dehumidification

When high outdoor humidity is a continuing problem, one option is to dehumidify the air, especially in basements. This can be accomplished by mechanical or chemical methods.

Mechanical dehumidifiers remove moisture by cooling the air. Moist air is pulled past cooling coils, water vapor condenses on the coil, then drips into a collection pan. The dry air is then exhausted back into the house.

At room temperatures of 65° or below, frost or ice will form on the cooling coils, and dehumidification stops until the unit is defrosted. Some units have an automatic defrost cycle, while others must be manually defrosted by shutting the unit down until the ice melts.

For good circulation, place the dehumidifier in the center of the room. For maximum effectiveness, close off the area to be dehumidified. Clean the coil, clean and empty the drainage pan regularly. Stagnant water can grow mold and bacteria, and can be a health hazard.

Chemical dehumidifying agents, known as "desiccants," absorb moisture out of the air. Desiccants are a good option to small, confined places like closet, but they can be dangerous to children and pets. Some desiccants are very corrosive and must be handled with extreme care. Others are reusable and nontoxic, but hands should be washed thoroughly even after handling the nontoxic variety.

Household moisture sources

Moisture source		Estimated amount (pints)
Bathing: tub (excludes towels and spillage)		0.12/standard size bath
	shower (excludes towels and spillage)	0.52/5-minute shower
Clothes washing (Automatic, lid closed, standpipe discharge)		0 +/load (usually nil)
Clothes drying:	vented outdoors	0 +/load (usually nil)
	note vented outdoors or indoor line drying	4.68 to 6.18/load(more if gas dryer)
Combustion - unvented kerosene space heater		7.6/gallon of kerosene burned
Cooking:	breakfast (family of four, average)	0.35 (plus 0.58 if gas cooking)
	lunch (family of four, average)	0.53 (plus 0.68 if gas cooking)
	dinner (family of four, average)	1.22 (plus 1.58 if gas cooking)
	simmer at 203°F., 10 minutes, 6-inch pan (plus gas)	less than 0.01 if covered, 0.13 if uncovered
	boil 10 minutes, 6-inch pan (plus gas)	0.48 if covered, 0.57 if uncovered
Dishwashing:	breakfast (family of four, average)	0.21
	lunch (family of four, average)	0.16
	dinner (family of four, average)	0.68
Firewood storage indoors (cord of green firewood)		400 to 800/6 months
Floor mopping		0.03/square food
Gas range pilot light (each)		0.37 or less/day
House plants (5 to 7 average plants)		0.86 to 0.96/day
Humidifiers		0 to 120 + /day (2.08 average/hour)
Respiration and perspiration (family of four, average)		0.44/hour (family of four, average)
Refrigerator defrost		1.03/day (average
Saunas, steambaths, and whirlpools		0 to 2.7 + /hour
Combustion exhaust gas backdrafting or spillage		0 to 6,720 + /year
Evaporation from materials:		
	seasonal	6.33 to 16.91/average day
	new construction	10 + /average day
Ground moisture migration		0 to 105/day
Seasonal high outdoor humidity		64 to 249 + /day

Source: Minnesota Extension Service, University of Minnesota

Remember that dehumidification, whether mechanical or chemical, is treating the symptom and not the problem. It is only a temporary solution. Dehumidify only if you cannot solve the problem by reducing the amount of moisture in your home.

Paint problems

Exterior paint problems may or may not be caused by excessive interior moisture. Peeling, blistering, or cracking paint can point to a moisture problem, especially if the raw surface or wood is visible. Often, paint problems are severe on outside walls or rooms with high humidify and heavy air leakage.

Some paint problems are not recognized as being caused by interior moisture, and the problem is simply covered up with a new coat of paint or new siding. Of course, some paint problems are caused by poor application, or use of a paint that wasn't meant to do a particular job.

HOME ENERGY GUIDE

TECHNIQUES TACTICS & TIPS

Caulking & Weatherstripping

Minnesota Department of Commerce Energy Information Center

Air leakage can account for one third of the total heat loss in an average home. Warm air leaking out must be replaced with cold air drawn in, which has to be heated. Excessive air leakage may be costing you more than $100 every year if you are heating with natural gas, and even more with other fuels. Moisture also escapes with the warm air, and if it condenses inside the walls or in your attic, serious structural damage could result. Caulk and weatherstripping are materials designed to stop these air leakage heat losses, and can pay for itself in less than two years if the installation is done with care.

Common sources of air leakage are shown in Figure 1. Add up the small cracks and holes in your home and you could have the equivalent of a two-square-foot hole. This is like leaving a small window open all winter!

Before you begin your project, call the Energy Information Center and ask for the Home Energy Guide "Combustion Air." Appliances that burn wood, gas or oil, such as a furnace or water heater, need fresh air for proper combustion and exhaust. Unless you have recently replaced the furnace or water heater with a new sealed combustion or direct vent type appliance, you have a natural draft exhaust system.

Warning: It is possible to restrict the air leakage of the house enough to cause problems with a natural draft exhaust system.

Back drafting, poor combustion and dangerous build-up of combustion gases (including carbon monoxide) within the house is possible. Read the Combustion Air guide and follow its recommendations. Also, install a carbon monoxide detector near your water heater and furnace vent hood.

Locate the air leaks

Weatherstripping can be used to control air leakage at joints where two surfaces meet and move relative to each other, such as windows and doors. Weatherstripping is often the easiest and least costly way to control heat losses by air leakage, and it improves indoor comfort by reducing cold drafts.

The first step in weatherstripping is to determine where the air is leaking from your home. Air leakage can be detected by holding a smoking object, such as an incense stick, or a thin piece of thread near doors, windows and vents (see Figure 2). Drafts are shown as the thread or smoke moves with the air currents. Your electric or gas utility may provide a residential energy audit service which often includes a "blower door test." The test involves using specialized equipment to pressurize your house, which will measure the air leakage characteristics of your house and help identify the leaky spots.

For best results, choose a cool, windy day in the fall or a very cold winter day. Turn on all exhaust fans and the furnace and clothes dryer. This will increase the pressure difference and draw air out of the house so that outside air will come in at the air leakage points to replace it.

Related Guides
Attic Bypasses
Combustion Air
Home Heating
Home Cooling
House Diagnostics
Low Cost/No Cost Ideas
Windows & Doors
Indoor Ventilation
Home Insulation

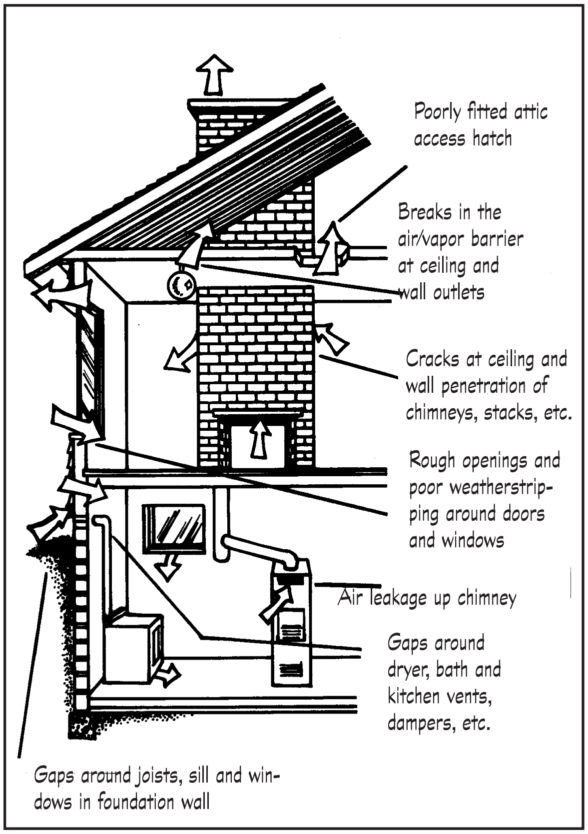


Figure 1:
Common air leakage sources

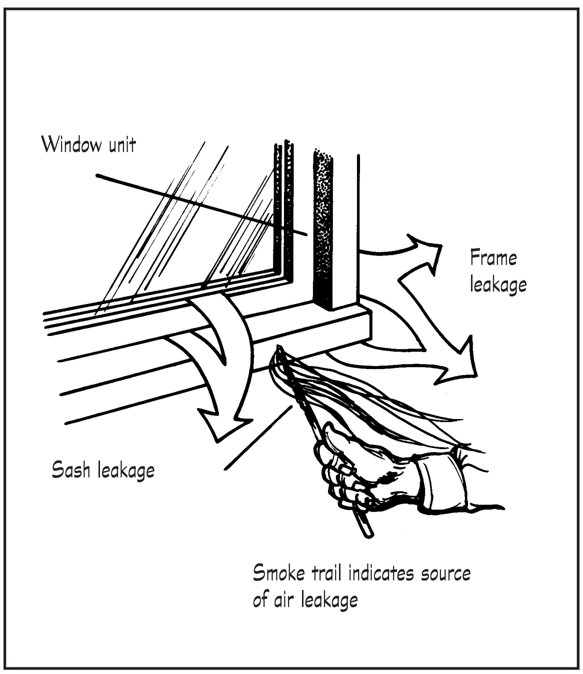


Figure 2

Move the thread or smoke source around window and door edges, electrical outlets and other potential leakage areas identified in this guide, and mark the drafty spots with chalk. Check the drafty areas on windows and doors to determine if there is any weatherstripping, if it is worn out and should be replaced or if it just needs adjusting.

Weatherstripping doors and windows. Extensive testing has shown that tubular weatherstripping provides the best seal. However, on doors or swinging windows, this type requires the most closing pressure, which may be difficult for children, handicapped or elderly individuals. Silicone, neoprene, urethane, or rubber strips are better in these situations.

Open-cell foam and felt strips need to be very tightly compressed to create an adequate seal. They will keep out dust, but are inadequate air barriers. Therefore, this publication highlights the installation of neoprene, urethane, silicone, or rubber strip, tubular and specialty types of weatherstripping, because these materials create good air seals with minimum closing force at all temperature ranges and have long, useful lives.

The type of window has a direct bearing on the type of weatherstripping to use. Double hung or vertically sliding windows can be weatherstripped with tubular or strip materials (Figure 3). The permanent or nonsliding sections can have air leakage eliminated with removable caulk.

Spring metal is the most durable but is difficult to install on existing windows. Tubular or plastic strips can be mounted on the inside or the outside, but in our extreme climate will last longer when installed on the inside. The meeting rails in the center of the vertical sliders are best weatherstripped with a tension strip.

Horizontal sliders are another common window; these include sliding glass doors. The ease with which weatherstripping can be applied depends on the type of sash. If not previously weatherstripped, wood or vinyl-covered wood windows are usually best fitted with angled strip materials (Figure 4). If existing weatherstripping is worn out, replace it with a similar type.

Metal or vinyl sash horizontal sliders are usually weatherstripped at the factory. However, if worn

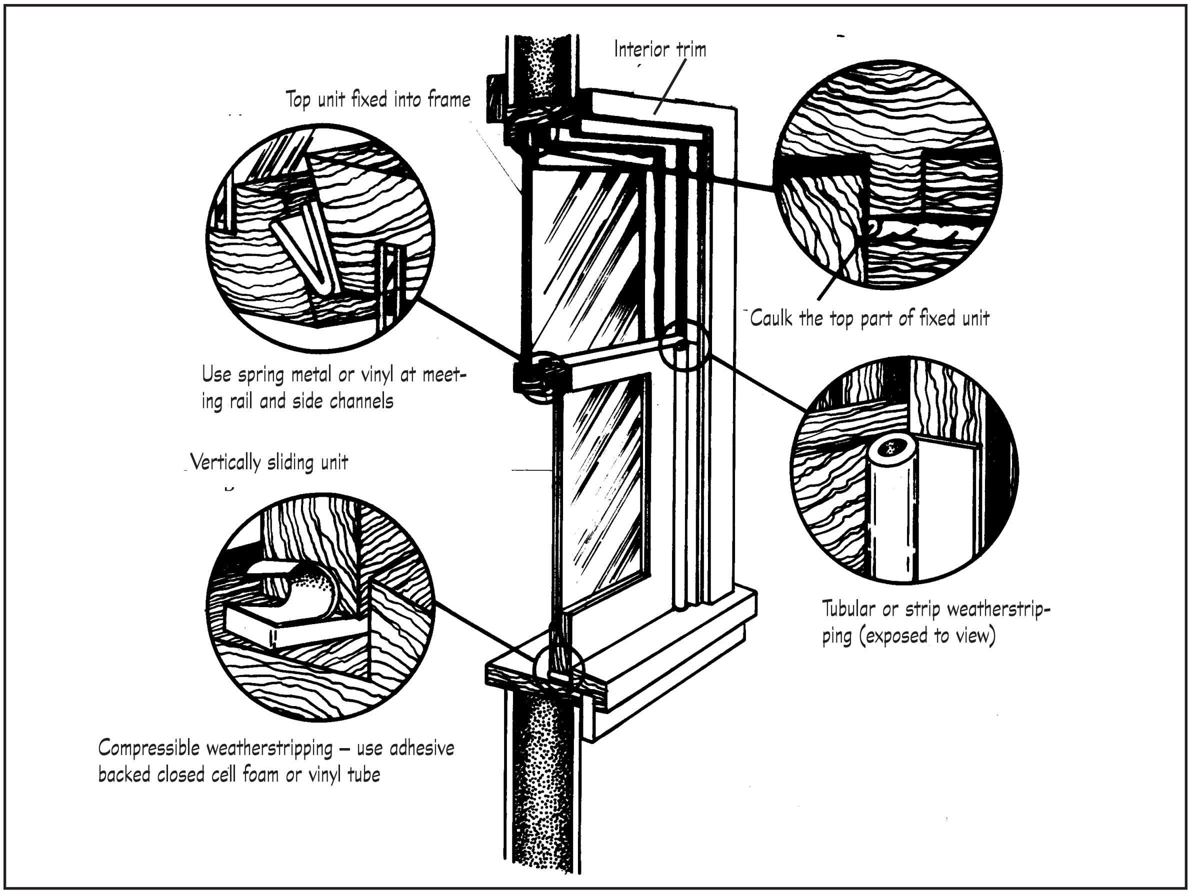
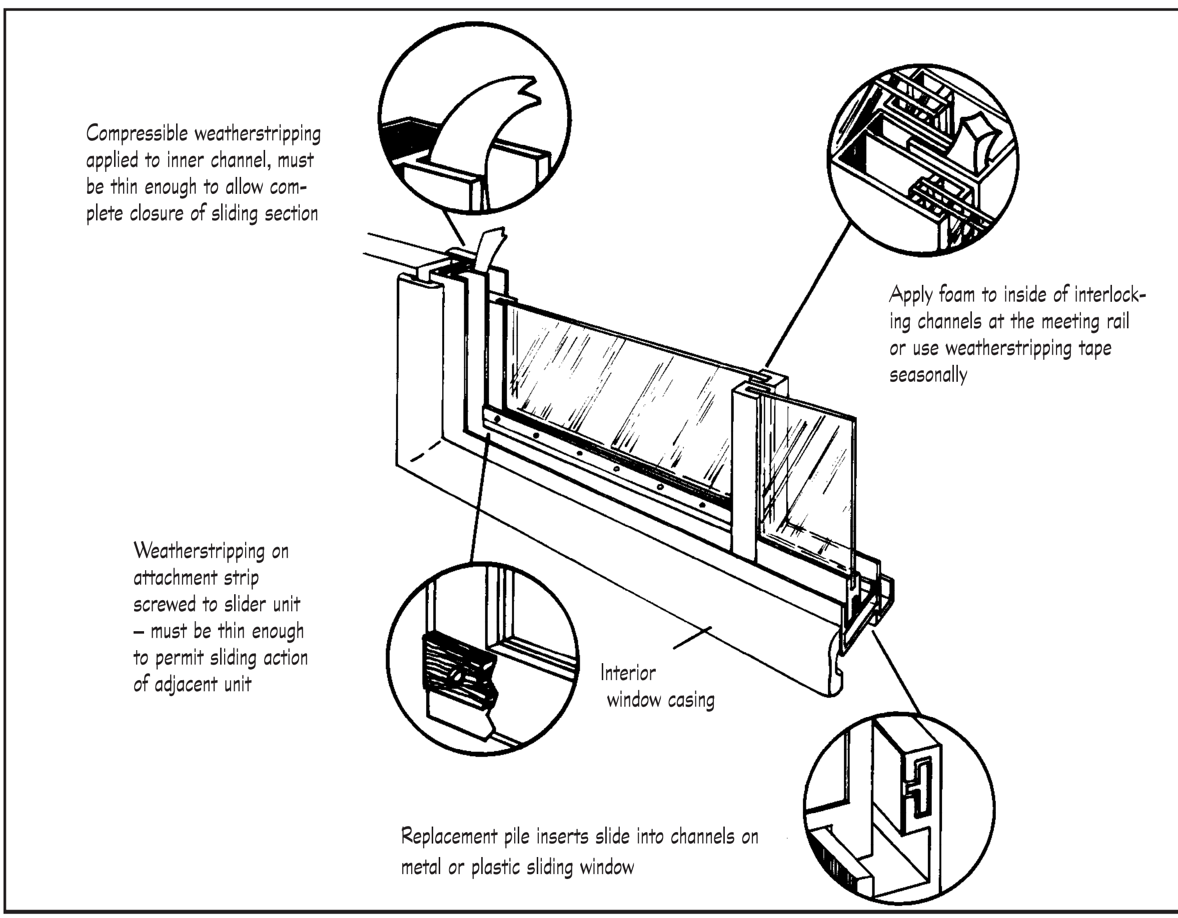


Figure 3: Typical double-hung window

Caution

Houses built before 1978 may contain lead-based paint. The older a house is, the more likely it is to have lead-based paint and high concentrations of lead in paint. If you work on windows that have painted trim, you need to control any dust and chips from the paint and dispose of them safely. Intact paint should not be removed. Pregnant women and small children should stay away from the work area until it is cleaned up. Information on lead is available from the Minnesota Department of Health at 612-215-0890.

Figure 4: Typical sliding window unit



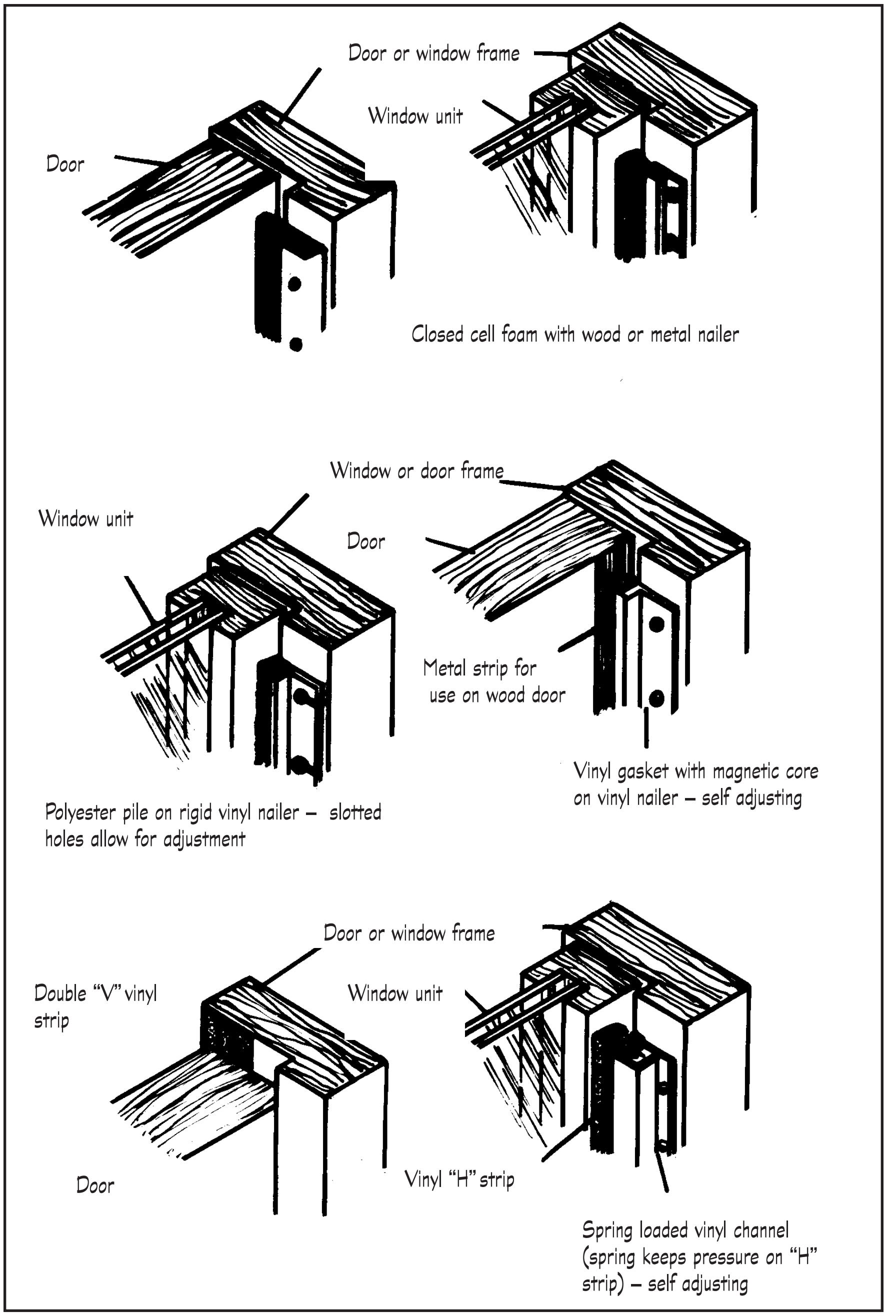


Figure 5:
Types of weatherstripping for doors or windows without existing seals

out or defective, the seals can usually be replaced by sliding new material into the old channels. Be sure to measure the width required so that you purchase the correct size.

Because there are so many types of sliding windows, some innovation may be required by the homeowner. For sliding windows or doors with large, leaky gaps, seal the channels with rope caulk or sealant-peel caulk (see elastomeric caulk in Table 3) in the fall and remove it in the spring. For narrower gaps in sliding windows, a weatherstripping tape can be applied in the fall and removed in the spring.

Warning: Always designate one window in each room as the fire escape and make sure it is operable by occupants.

Awning, hopper or casement windows that swing open can be weatherstripped like doors. Material is attached to the jamb, and the door or window closes against it. Figure 5 shows some types of jamb weatherstripping suitable for doors or swinging windows with no existing seals. Weatherstrip all sides, including the hinge side.

Most windows of this type are factory weatherstripped, but if the materials wear out, replace them with similar types. Before replacing spring metal or metal V strip weatherstripping, pry the existing strip apart to re-spring the strip. Select a material with slotted holes or a self-adjusting one so that future adjustments can be made to accommodate change, slight movement, warping or shrinkage.

New windows often have double weatherstripping; that is, two separate seals. This concept can be applied when upgrading existing windows. For swinging windows, put one strip of weatherstripping on the edge of the sash that moves and another compression strip attached to the jamb on the inside.

For a better seal when applying any weatherstripping, clean the attachment surface and apply a bead of caulk under the weatherstripping where it is attached to a flat surface.

Weatherstripping bottoms of doors. The bottoms of doors, unlike jambs, are subject to wear and therefore the weatherstrip must be more durable. There are two ways to strip this area; by using a threshold or by attaching a door bottom or sweep (Table 2).

Try to choose a threshold or door bottom that does not require trimming the door. Some will adjust to accommodate different clearances (Figure 6), but others will not. Door sweeps require no clearance, because they attach to the side of the door.

Thresholds are generally installed to replace existing worn out ones. Often only the vinyl or rubber weatherstripping is defective, not the entire assembly. Check to see if new inserts can be purchased separately. If the whole threshold must be replaced, select one with replaceable gaskets.

Door bottoms or sweeps are usually installed on doors with no existing bottom weatherstripping. They are installed flush with the floor or threshold of the existing sill to provide a positive seal against air movement. Select a sweep or door bottom that can be adjusted to compensate for wear and movement.

Because doors will change dimensions with changing temperatures, self-adjusting weatherstripping is a good choice.

Weatherstripping other openings. Other "door-type" openings in your home include attic hatches and mail chutes. The doors of mail chutes can be weatherstripped with the same jamb materials described for windows and doors. If the chute is no longer in use, fill the box with insulation and seal the inside door with caulking.

Attic access hatches should be weatherstripped with compressible tube or strip products installed as shown in Figures 5 and 7. If the hatch is not heavy enough for a tight seal, add weight to it, use fasteners or screw the hatch securely closed. The hatch must also be insulated adequately. Check the HouseWarming guide, "Attic bypasses," for details on sealing attic air leaks.

Other openings to the exterior include exhaust fan dampers. These cannot be weatherstripped, but make sure they are closed when not in use by feeling for any air leaks or drafts. A dust or lint buildup around the closing flap or a bent, sticking hinge may be preventing the flap from closing completely. Clean and adjust the dampers to correct this problem. An old toothbrush works well. The complete duct run from your clothes dryer should also be cleaned regularly to prevent a lint buildup around the damper.

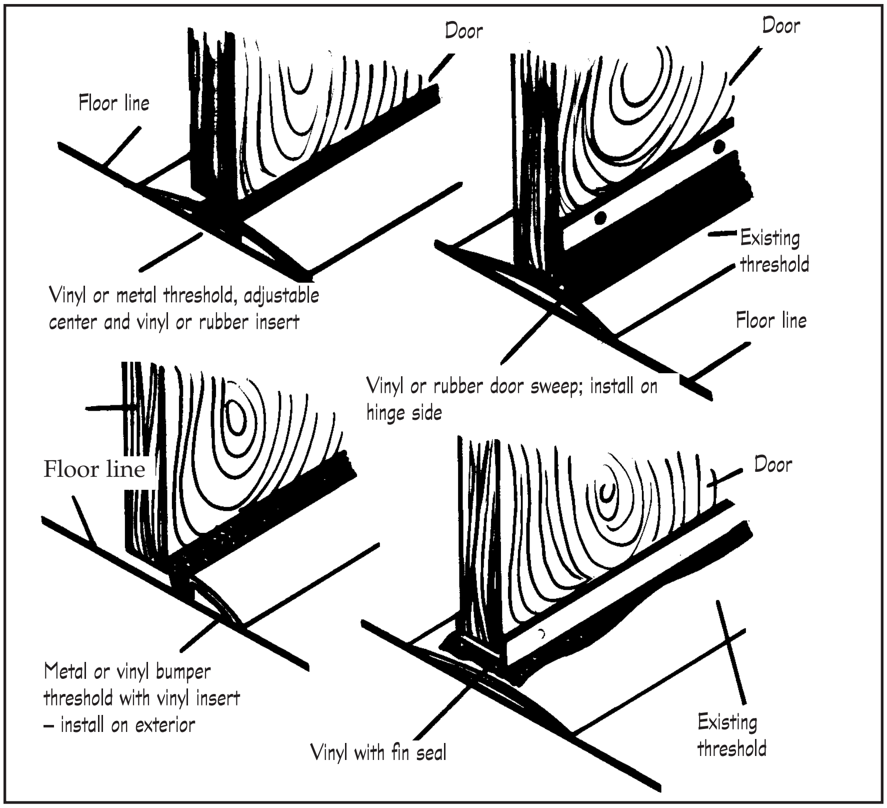


Figure 6:
Door bottoms

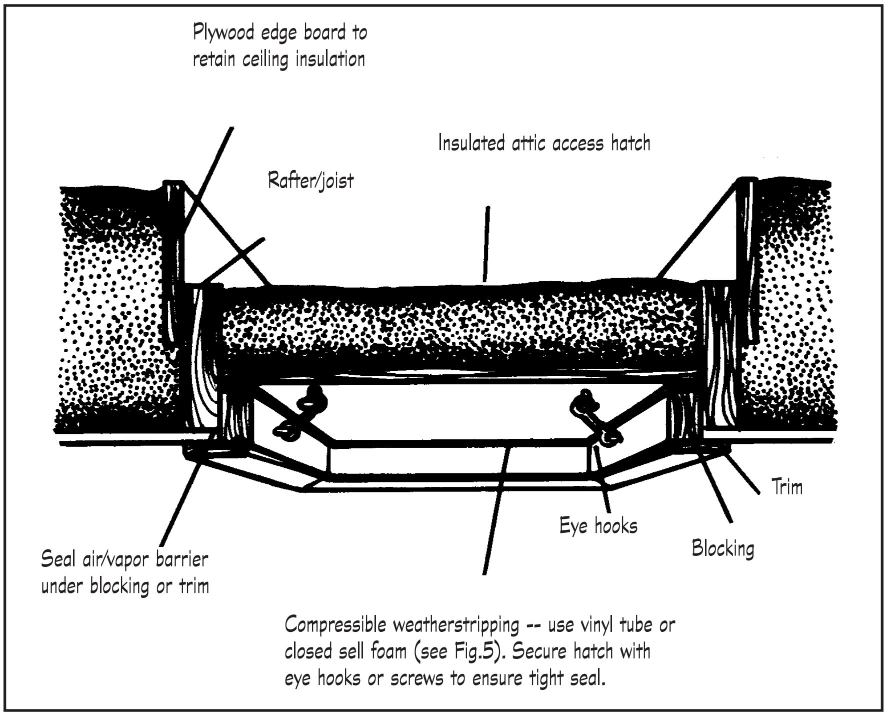


Figure 7:
Attic hatch

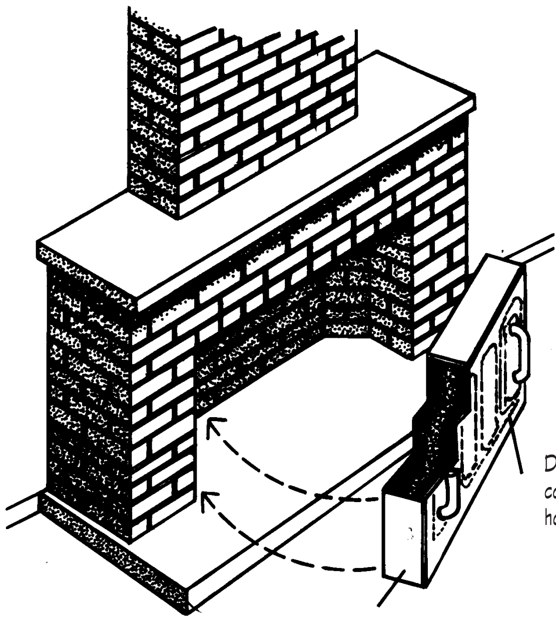


Figure 8:
Fireplace opening

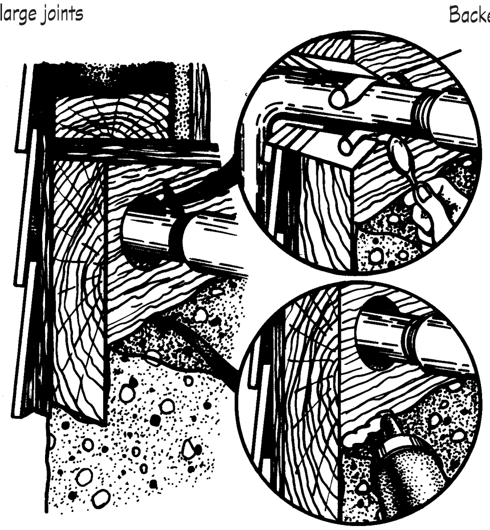


Figure 9:
Applying caulk

The damper in the fireplace chimney should also fit tightly. Using a light, check for any gaps caused by debris buildup, warping or poor construction. This damper cannot be weatherstripped, or have gaskets, but can be cleaned or adjusted for a better fit. Another alternative would be to install a new damper on the top of the chimney. You can also build a decorative, insulated fireplace "plug" to insert into an unused firebox opening (see Figure 8). The plug will prevent heated room air from constantly rising up the fireplace chimney around a poorly fitting damper.

Caulking

Caulk is applied where two non-moving surfaces meet, such as at sill plates or duct outlets. Caulking requires a little more effort and skill than weatherstripping, but is just as effective in cutting heat losses. Some areas, such as plumbing stacks, chimneys or electrical outlets, require specialized or combination weatherstripping and caulking techniques.

Houses are built of a number of different materials. Because these materials expand and contract at different rates with temperature and moisture changes, cracks and gaps may occur. Exterior gaps are a concern because water can penetrate the structure and cause deterioration. Interior gaps are a concern because air leakage causes heat loss, and the heated air carries moisture which may condense in the wall and cause structural damage.

The best place to seal with caulk is on the inside, to prevent moisture accumulating in wall and ceiling cavities. Interior sealants, though not subject to the same severe weather conditions as exterior types, should be chosen for their ability to maintain a good degree of flexibility and adhesion over a long period of time.

The preferred type of interior sealant will depend on its use. Factors to consider include whether the sealant will be exposed or concealed, the width of gap, types of adjacent materials and whether a high degree of flexibility is required. Table 3 gives the characteristics of available caulking materials.

Before using caulking materials, note the following points:

- Remove old caulk completely.
- Make sure all surfaces are dry and free of dirt, loose materials, grease or oil. Wipe with rubbing alcohol.
- Do not apply caulk at temperatures below (50°F) unless otherwise specified on the label.
- Always read the label to see if the caulk you are using is flammable, irritating to the skin or gives off dangerous vapors, and handle it accordingly.
- If priming is required, paint two light coats of alcohol shellac or a primer recommended by the manufacturer.
- Choose a caulking material suitable to the size of the crack to be filled and compatible with the materials it is to adhere to.
- Tape the edges of the crack to keep caulk off adjoining surfaces.

Practice may be required before you can create a neat, uniform bead when using a caulking gun. The nozzle should be cut at a 45 degree angle. Since the nozzle is tapered, cut it at the point that will give the width you require – near the narrow end for a small bead, farther up for a wider bead. The caulking material should be pushed out the nozzle as you apply steady pressure on the trigger, holding the angle of the gun constant and moving ahead at an even rate. The resulting bead should provide a good seal. Be careful to have enough caulking to accommodate shrinkage or joint movement (Figure 9).

Smooth the bead with a wet finger or use a plastic spoon for toxic materials such as silicone or oil based caulk.

For gaps larger than 3/8 inch in width or depth, polyurethane foam can be used. Other caulks will require a backer material such as rope caulking or foam weatherstripping to reduce the depth. Caulking will crack if you do not completely fill the crack.

When you are finished, seal the tip of the caulking gun tightly after cleaning out excess caulk. Shelf life for most unopened caulk is two years. For clean-up, check directions on the tube.

Sealing the rim joist space and the attic. A great deal of air leaks into your house in the rim joist area in the basement, while much warm air is lost into the attic. When sealing these areas, take care not to compromise the combustion air supply needed by your gas burning appliances. Consult the Basement Insulation and Attic Bypasses HouseWarming guides for step-by-step instructions for sealing basement and attic air leaks.

Sealing around window and door openings. The installation space or rough opening around windows and doors is a major area of air leakage. Usually insulation has been stuffed into a crack; this insulates but does not stop the air flow. This leakage can be stopped by using the method detailed in Figure 10.

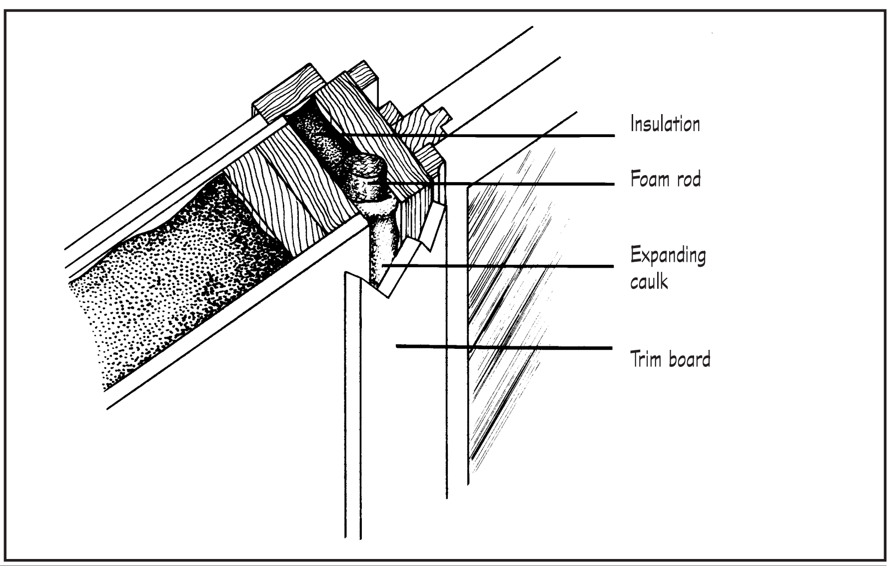
It is most convenient to improve the seal around doors and windows of older homes when the trims are removed for repainting or are being replaced.

Sealing loose panes of glass. If any glass panes are loose in their wood frames, new caulking is required to stop air leakage. Putty compounds and glazing points are most often used and are the least expensive solution. For information on reglazing, consult the home repair books in your local library, or locate a window dealer in the yellow pages. (Look under Window, replacement.)

Tip:

Caulk is cheap— and it provides a big return on investment and comfort as well.

Figure 10:
Pre-formed foam rods and expanding urethane foam can be used to seal the gap between the window and the wall.



Caulking Steps

- Check potential areas of air leakage and identify the worst sources.
- Weatherstrip around moving parts of windows, doors and hatches.
- Caulk around door and window trim.
- Check vents and dampers on fans, fireplaces and dryers.
- Caulk cracks and around outlets, vents and pipes penetrating the house exterior. Remember to do ceiling penetrations as well.
- Test again for effectiveness of sealing, or hire a professional to conduct a blower-door test for you or arrange for an energy "audit" through your electric or gas utility or community energy program.
- Increase the fresh air supply to control condensation, especially on windows. This may require adding a fresh air supply to older homes.

Glass panes in metal and vinyl frames are best sealed with vinyl strips. The strips are durable and should not require replacement during the life of the window.

Sealing wall outlets and switches. Outlets and switches on walls are another source of heat loss. Some tests indicate that up to 20 percent of the total air leakage heat losses in existing houses can occur through the outlets. If there is a gap, use commercially available, inexpensive gaskets between the plate and wall.

Disconnect the power to any outlets you are working on. Electrical codes forbid placing any object inside the boxes, so all sealing must be external. Child "safety plugs" can also be placed into unused outlets to stop air flow through the outlet holes.

If you are removing wall finishes, renovating or installing new wiring, you should install a vapor barrier behind new electrical boxes. Use the commercially available polyethylene box covers. Seal the box covers to the wall vapor barrier with an acoustical sealant before covering the walls.

Seal other penetrations into the house, such as plumbing and electrical openings, with caulk.

Conclusion

The costs associated with weatherstripping and caulking are small. Installation takes time, but is not difficult and fuel savings are considerable. Improving air tightness should be considered a must for making your home comfortable and energy efficient.

Table ONE: Weatherstripping

Tape (Cloth or plastic)
- use on any non-opening window or door
- good for one season only
- quick and easy to install
- remains in full view
- may remove paint when peeled off
- inexpensive

Gasket (Felt)
- use on windows, doors and attic hatch for compression fits
- poor durability and air seal
- must be nailed, stapled or glued
- made from wool, hair, cotton or polyester
- inexpensive

Gasket (Foam adhesives)
- use on windows, doors and attic hatch for compression fits
- available in open or closed-cell types
- closed-cell is more durable
- quick and easy to install
- hidden from view
- moderately expensive

Gasket (EPDM rubber adhesive)
- use on windows and doors for compression fit
- good durability and air seal
- quick and easy to install
- hidden from view
- inexpensive
- good durability

Gasket (Foam on attachment strip)
- use on windows and doors for compression fit
- more durable than adhesive type
- must be nailed or screwed
- hidden from view
- moderately expensive
- good performance

Tubular (Filled core)
- for windows or doors
- good durability and air seal
- must be nailed or stapled; in full view
- made with rubber, plastic or vinyl
- difficult to compress
- moderate to expensive

Tubular (Hollow core)
- for windows or doors
- good durability and air seal
- must be nailed or stapled; in full view
- made with rubber or vinyl
- moderately expensive

Tubular (Hollow on attachment strip)
- use on windows and doors
- good durability and air seal
- usually nailed or screwed; in full view
- slotted holes allow for readjustment
- made of rubber or vinyl with aluminum or vinyl attachment strips
- expensive

Strip (Tension-spring metal or V-strip)
- use on windows and doors; especially good for the gap where the sash of double hung windows meet
- excellent durability and good seal
- must be nailed if metal, or adhesive
- if vinyl, invisible when installed
- hidden from view
- double strip vinyl available for a better seal
- moderate to expensive

Strip On attachment (pile or fin)
- use on windows and doors; especially good for sliding windows
- moderate to good seal and durability
- must be nailed or screwed in full view
- made with vinyl rubber or polyester pile with fin seal on a wood, vinyl or aluminum attachment strip
- moderate to expensive

Specialty (Spring loaded)
- use on windows or doors
- excellent durability and seal
- must be nailed or screwed
- made with aluminum and vinyl
- very expensive

Specialty (Magnetic strip)
- use on windows and doors
- excellent durability and seal
- must be nailed or screwed
- made with aluminum and vinyl
- very expensive

Can you over-seal your home?

It is difficult, but possible to seal an existing house to the point that the air supply to combustion equipment is restricted or humidity and condensation problems occur. In newer homes, or with a furnace replacement, there should be a separate combustion air supply installed for the furnace so that sealing the home will not affect performance.

All homes should have mechanical ventilation so that kitchen and bathroom moisture can be sent rapidly out of the house. Excessive condensation, such as large amounts of ice on the inside of windows or mold growing on indoor surfaces, may also have causes other than a tight house. Storing wood in the house, boiling water for meals and other lifestyle issues can lead to indoor moisture problems. If you have excessive moisture, call the Energy Information Center and ask for a Home Moisture guide.

Table TWO: Weatherstripping for door bottoms

Saddle Threshold

- requires minimum clearance of 5/8 inch
- may have adjustable insert (up to 1-1/4 inch)
- check that replacement gaskets are available
- good durability and seal
- made with vinyl or rubber and aluminum base
- installed with screws
- expensive
- look for a thermal break on metal thresholds

Bumper Threshold

- bottom clearance not required
- can be damaged by trapped stones, etc.
- check that replacement gaskets are available
- good durability and seal
- made with vinyl or rubber on a vinyl, wood or aluminum attachment
- installed with screws on interior of door
- moderately expensive

Door Bottom

- requires minimum clearance of 1/4 to 1/2 inch
- some types can be used as a threshold
- check that replacement gaskets are available
- must remove door to install
- made with rubber, metal, vinyl or felt on aluminum or vinyl base
- moderately expensive

Door Sweeps

- good to use for uneven floors
- adjusts for sweeping over deep carpet
- easy to attach; may be adhesive backed, nailed or screwed
- attach to inside face of in-swinging door
- fair to good durability and seal
- made with vinyl, rubber or polyester pile on an aluminum vinyl or wood attachment strip
- generally the least expensive type

Table THREE: Types of Caulk

Oil/Resin Base

- durable for 1 or 2 years
- bonds to most surfaces although may stain unprimed wood surfaces
- difficult to apply; sticky
- takes up to 1 year to cure
- forms hard surface when dry
- should be painted
- low cost

Latex base (acrylic or non-acrylic)

- durable for up to 10 years
- bonds well to porous surfaces such as wood or concrete but not to metal
- easy to apply; does not require primer
- do not use in high moisture environments (showers); susceptible to mildew
- fast curing
- forms hard or flexible surface when dry; use for small movement joints between similar materials
- comes in colors or can be painted
- most types clean up with water, or use paint thinner
- medium cost

Butyl Rubber

- durable for 5 to15 years
- bonds well to all surfaces but tends to shrink
- does not require a primer
- will stick to air/vapor barrier
- more difficult to apply
- slow to cure
- flexible when dry; use for small-movement joints
- clean-up with paint thinner
- can be painted; also comes in colors
- medium cost

(con't) Table THREE: Types of Caulk

Elastomeric (silicone, polysulphide)

- durable for more than 20 years
- bonds to most surfaces; requires primer for some plastics, masonry and other porous surfaces (specialized sealants are available)

Elastomeric

- won't seal over itself without a primer
- difficult to apply in cold weather
- may be irritating during application and curing
- high moisture resistance
- takes up to 3 days to cure
- nontoxic when cured
- ventilate area when applying
- little shrinkage; remains flexible when dry; use for large movement joints
- needs special cleaner for tools and hands if not cleaned with water before curing
- high cost

Polyurethane foam

- available in aerosol cans
- specialized for large gaps
- when applying, make sure area is well ventilated
- use gloves when applying
- requires care when applying as it expands 2-1/2 times
- may degrade in sunlight
- bonds to most surfaces
- requires a primer before use on pressure treated wood or vinyl
- flammable; must be covered by drywall on interior
- has high insulation value
- high cost

Polyurethane, gunable

- use in standard caulk gun
- bonds to masonry
- may require primer
- may be thinned
- durable for up to 20 years
- paintable
- may take a long time to cure

Acoustical sealant

- durable for more than 20 years
- only available in large tubes; needs large gun
- interior use only
- excellent for joining air/vapor barrier
- easy to apply, but messy
- non-hardening; must be covered
- need special cleaner (paint thinner) for tools and hands
- low cost

Rope or cord

- specialized product for larger gaps
- if not sealed, can be used temporarily, then removed and reused
- should be protected by sealant or covering
- low cost

Caulking Tips

It's advisable to seal "attic bypasses" first, before caulking windows and doors.

The best place to seal with caulk is on the inside.

This Home Energy Guide was adapted from the publication "Caulking and Weatherstripping," courtesy of Alberta Department of Energy and Natural Resources.

HOME ENERGY GUIDE

TECHNIQUES TACTICS & TIPS

Save Energy with Trees

Minnesota Department of Commerce Energy Information Center

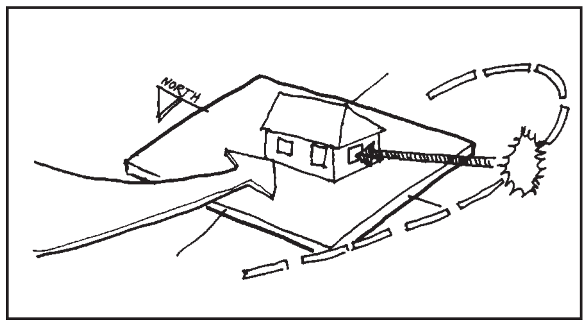
Trees shade our homes in summer and shelter us from harsh winter winds. Estimates indicate that in Minnesota, strategically placed shade trees could reduce an air conditioning bill by up to 25% and a windbreak could reduce annual fuel bills by up to 10 to 20%. A tree-canopied neighborhood is cooler in the summer and winter winds are cut in half. When summer temperatures are cooler, fewer air pollutants form. Thus, trees create more comfortable and cleaner places for people to live.

How your home uses energy

Our summers may be hot and sticky, but Minnesotans typically spend about ten times more for heating, than cooling, even when their homes are fully air-conditioned.

Winter heating factors

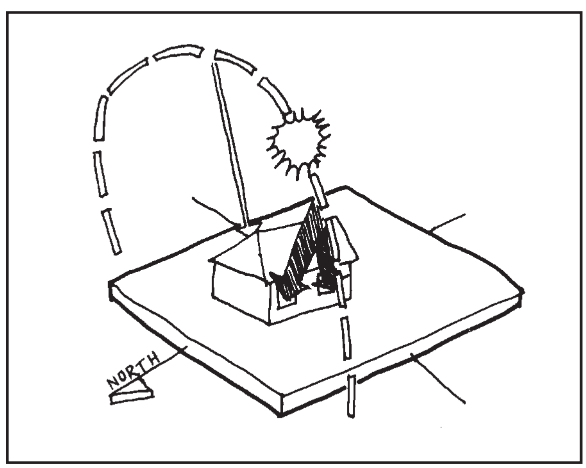
The temperature of our homes in winter is affected by the sun and wind. Homes can gain significant amounts of solar energy from the sun shining through south windows in the winter when the sun is low in the sky. East and west windows will also provide modest solar gains in winter. This free energy may represent 5 to 20% of the energy needed to heat a typical Minnesota home. Cold wind leaking into a home and warm air escaping outside is the most important factor increasing heating costs, accounting for 25 to 40% of the heating load. The wind has the most effect when its velocity is greatest and when the temperature difference between inside and outside is greatest.



Northwesterly winds cause the most heat loss in winter, but the sun's path low in the southern sky contributes significant free solar energy through south windows.

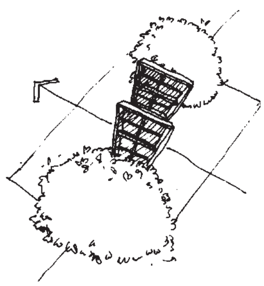
Summer cooling factors

Because our homes are well insulated, very little of the sun's energy comes through a home's roof and walls. About half of the unwanted heat in a home in the summer comes from sun shining through the windows, but less than 5% comes

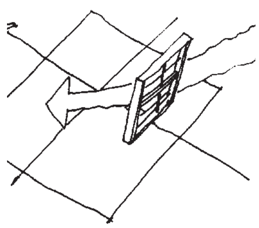


Most unwanted summer heat comes through east and west facing windows and almost no heat makes it through well-insulated roof and walls.

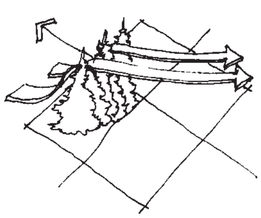
Related Guides:
Windows & Doors
Home Cooling
Home Heating



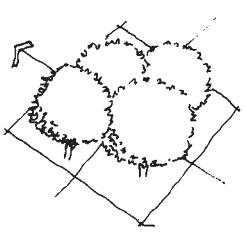
Shade west and east windows



Avoid trees south of windows



Create windbreaks

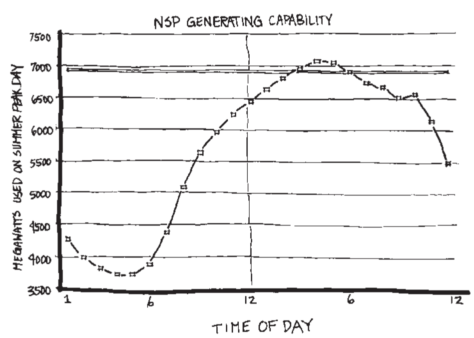


Increase tree canopy

through roof and walls combined. Because of the angle of the sun, nearly twice as much of the sun's energy strikes the east windows in the morning or the west windows in the afternoon as hits the south windows. Broad roof overhangs on the south further reduce the sun from shining in south windows.

Peak electricity use

The highest use of electricity occurs late in the afternoon on the hottest days of the year when air-conditioning use is highest. To avoid or delay the need to build costly new power plants to meet peak demand, afternoon shading of west-facing windows to reduce air conditioning use is most important.



Electricity use peaks on the hottest summer days in later afternoon (as shown for NSP's day of peak electrical demand in 1991).

Strategic Shade

The most critical actions for planting for energy conservation

- shade west and east windows
- avoid trees south of windows
- create windbreaks
- increase tree canopy

Deciduous trees that provide maximum summer shade and minimum winter shade are ideal for reducing air-conditioning use, but they must be located and selected properly for best year-round results.

Shade west and east windows

Give highest priority to planting shade trees due west of west windows. Planting shade trees due east of east windows is second priority. Select a tree that can be planted within twenty feet of the window and will grow at least ten feet taller than the window. When space permits, use as many trees as needed to create a continuous planting along all major west and east facing windows.

Avoid trees south of windows

Contrary to intuition, the worst place to have a tree from an energy-saving perspective is out in the yard south of a home. In summer when the sun is high in the sky at midday, the shadow of a tree falls directly under the tree and entirely misses a home to its north. In winter, however, the shadow of the same tree will fall on the house throughout most of the day. To avoid shading south windows, any trees south of the home should be located at least twice their mature height away from the house.

Prune lower branches of trees near south windows

Any trees on the southwest or southeast sides of the home should be pruned as they grow to remove their lower branches to allow more winter sun through; however, lower branches on trees northwest of the home are desirable to create the most shade in late afternoon. Large deciduous trees very close to the south side of the building can have their lower branches removed to allow more sun to reach the building in winter.

Shade air conditioners, parking places and paved areas

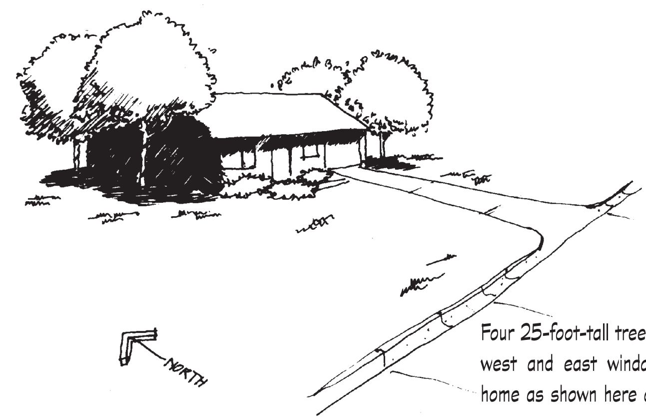
An air conditioner runs more efficiently if it is in a cooler environment. Less air conditioning is used to cool a car if it was parked in the shade. The air heats up immediately around paved areas like driveways and patios. Therefore, locate paved areas and air conditioners away from south windows and shade them with trees.

Use solar friendly trees

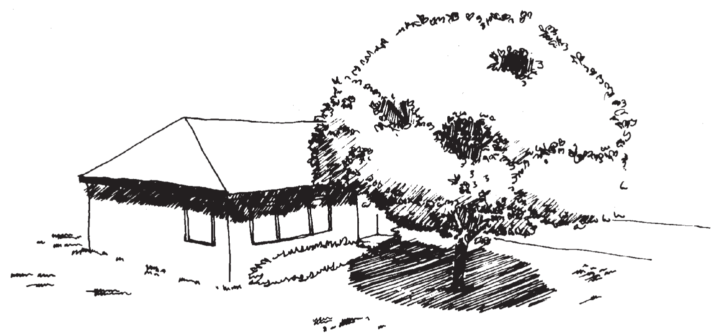
For greatest benefit, a shade tree should have a broad crown of dense foliage during the hottest times of the year. It should lose its leaves just as the thermostat kicks on the furnace in the fall, and in winter its branches should be sparse. Trees that best meet these characteristics are the most "solar friendly." The amount of sun blocked by a mature deciduous tree in summer ranges from about 60 to 90%. A mature tree's branches and twigs typically block 30 to 50% of the sun–a significant reduction in beneficial free solar energy over our long winters.

The most solar friendly species inherently have denser foliage and a more open winter form, giving them a good summer to winter ratio of crown density. This is true of trees with compound leaves that shed more of their branching structure each fall. Examples are Kentucky coffeetree, walnut, and ash which have moderately dense summer shade with sparse winter branching. Other desirable trees, such as sugar and red maple, have denser summer shade with moderately open winter branching.

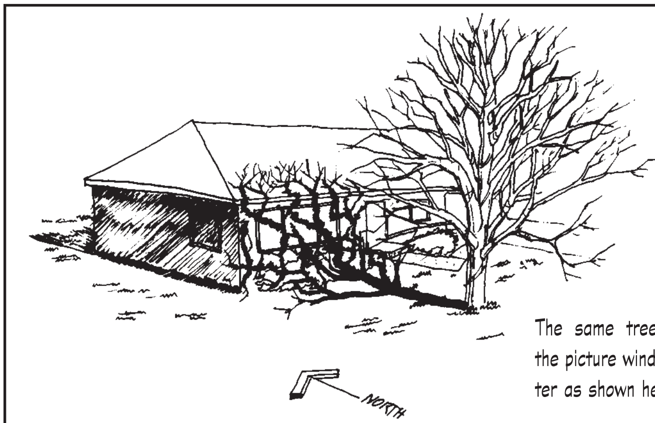
The foliage of solar friendly trees should be there when it is needed most. For a northern climate, this typically favors trees that leaf out moderately



Four 25-foot-tall trees effectively shade the west and east windows of this one-story home as shown here at 3 p.m. in July.



The shadow of a 25-foot-tall tree located 20 feet south of a home completely misses the home in summer as shown here at 3 p.m. in July



The same tree detrimentally shades the picture window throughout the winter as shown here at noon in January.

This tree shading an air conditioner still allows good air circulation.

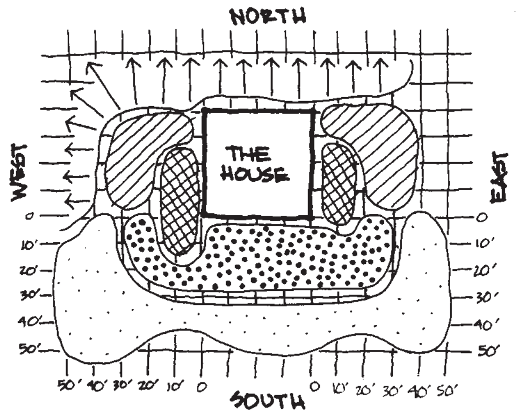
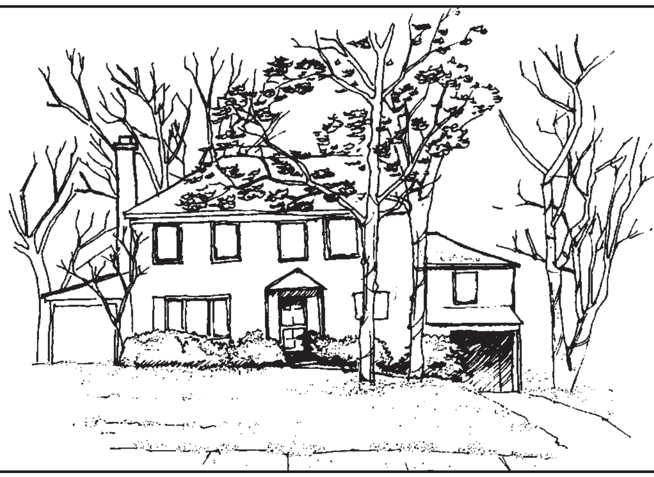


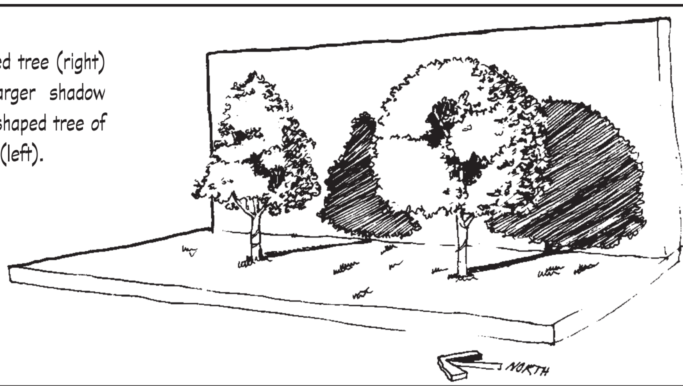
Diagram 1
Use this map to strategically locate trees. The grid marks 10-foot increments going out from the house. For example, the best locations for shade trees are 10 to 15 feet due west and east of the house.

Oak in front of home before pruning.



Oak in front of home after pruning

A broader crowned tree (right) casts a much larger shadow than a pyramidal shaped tree of the same heights (left).



late in spring and drop their leaves fairly early in fall. The worst choices are non-native deciduous trees, such as Norway maple, that may wait until November to lose their leaves, and those oaks that retain their leaves through the winter. Species that naturally grow over a large geographic area may have many different cultivars that vary significantly in the timing of leaf drop. For example, some types of red maple lose their leaves a month later than others. Thus, whenever possible, select trees from northern seed sources.

Choose the right tree for the right place

Generally, the bigger the tree, the more environmental benefits it provides. Select a tree that will grow as big as growing space permits. Remember, a tree needs space for both branches and roots. Since the most beneficial locations for shade trees are close to the east and west sides of buildings, the best trees will be strong, resisting disease and pests and damage from storms. Many species are inherently more appropriate for energy-conservation plantings. Others are not desirable as strategic shade trees for various reasons: because they keep their leaves in winter (such as many oaks), because their branching is too sparse (such as a ginkgo), because their form is too narrow to cast the best shadows in the summer and their branches too dense in winter (like the Greenspire linden), or because they grow too large and weak wooded to be planted very close to a building such as silver maple and cotton wood). Trees are more healthy and vigorous when they are well suited to the site's soil and climatic conditions, so check with a local forestry or landscape professional before making your selection.

Wind shelters

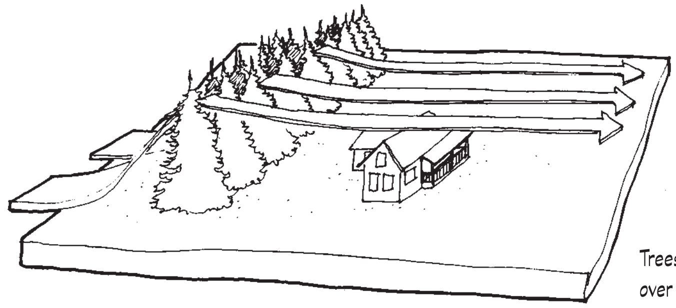
Trees are ideal wind filters. They are large, with branches and twigs which bend in the wind, gently breaking its force with minimal turbulence. A shadow of relatively calm air extends downwind from a windbreak about ten times the height of the trees. Nothing people can build could be as cost-effective as trees in sheltering homes and neighborhoods from the onslaught of harsh winter winds.

Plant all dense trees upwind

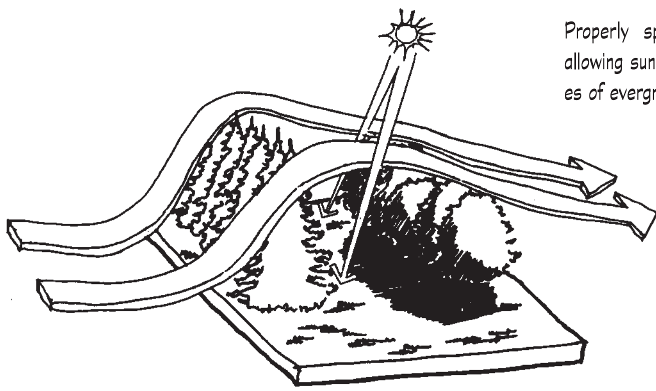
For maximum wind protection, trees need to be dense enough, tall enough, and there needs to be enough of them. The ideal windbreak tree is a dense evergreen whose branches extend from ground level to a height at least twice as tall as the building being sheltered. Windbreak trees need to be clustered together to reduce wind going between the trees. The most efficient way to do this is to plant trees in rows perpendicular to the primary winter wind direction–usually running along the west and north sides of the property. Since the wind will increase some at the edges of the windbreak, not only should the trees be taller, but the windbreak should be much longer than the buildings being sheltered. To keep dense branches to the ground, evergreens need full sun which means they must not be overcrowded. Select windbreak trees from the recommended list that are best adapted to the site's growing conditions so they will be tall, yet dense.

Create a shelterbelt on a large site.

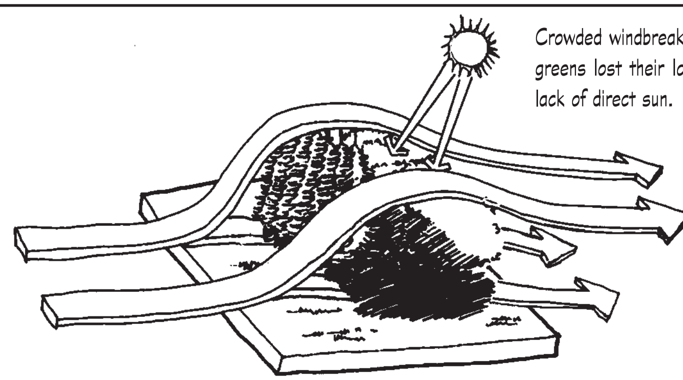
Where enough land is available, plant a multi-row shelterbelt like those traditionally used around farmsteads. A shelterbelt can be used for a single rural residence or to shelter a whole neighborhood. A shelterbelt may have up to seven rows of trees and be several hundred feet long. Most rows are evergreen trees at a recommended spacing of twenty feet apart within and between rows. Some rows may consist of larger or faster growing shade trees which must be spaced far enough from the evergreens to minimize detrimental shading. On the open prairie, shelterbelts not only stop the wind, they stop the snow. Therefore, a row of shrubs is used just inside or outside the trees and typically the home is downwind from the trees at least fifty feet.



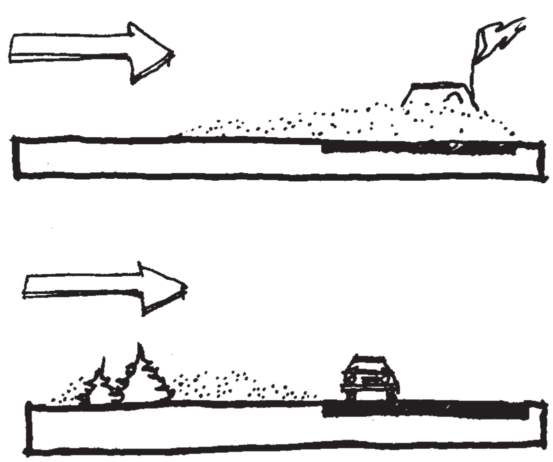
Trees guide the wind over the building.



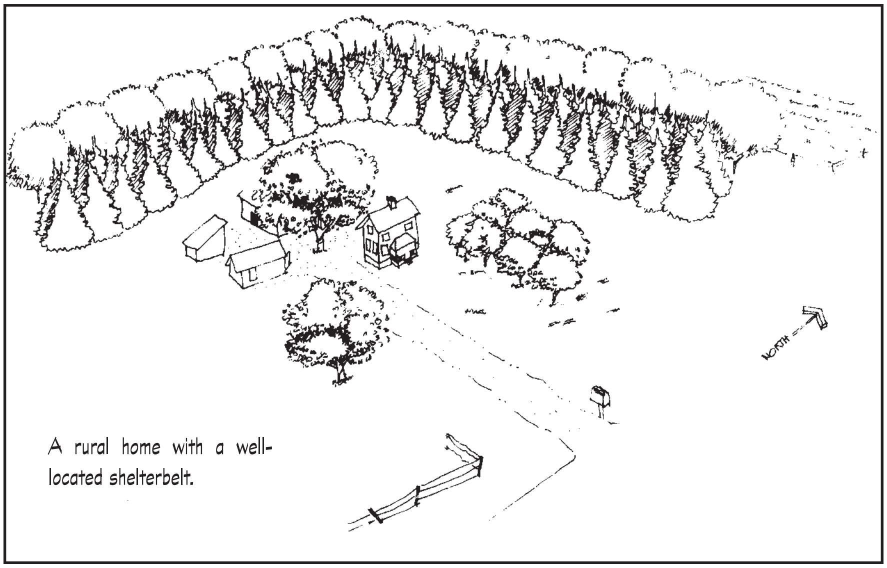
Properly spaced windbreak rows allowing sun to reach lower branches of evergreens.



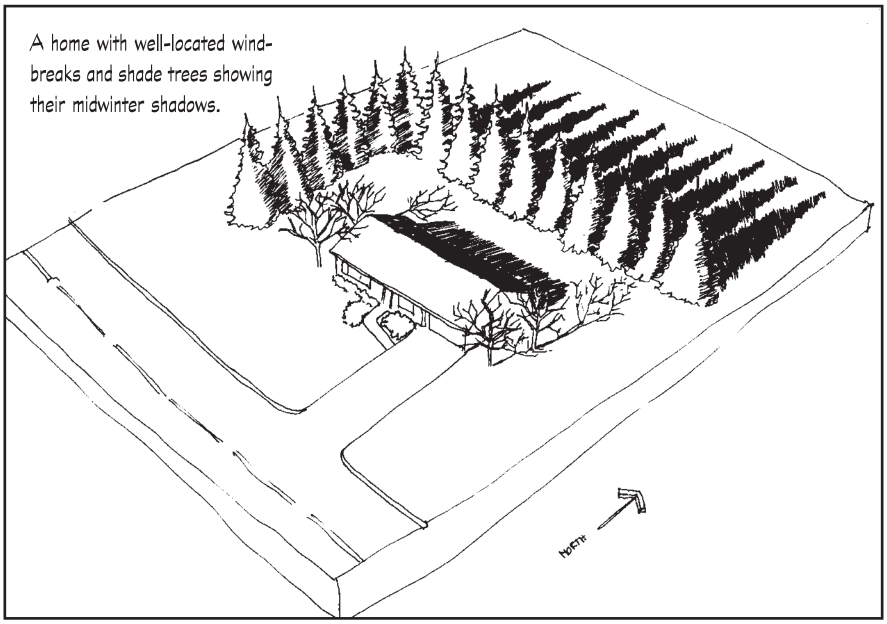
Crowded windbreak rows whose evergreens lost their lower branches from lack of direct sun.



Drifts across an open road vs. plants catching snow.



A rural home with a well-located shelterbelt.



A home with well-located windbreaks and shade trees showing their midwinter shadows.

Create a windbreak in a residential yard

A home on a site of a quarter-acre or so should have a room for a windbreak along its west and/or north side. The same principles apply as in a shelterbelt, but less space means fewer rows of trees. Giving evergreens plenty of sun to keep their lower branches is particularly important. With a one or two row windbreak, as long as the evergreens receive direct sun on the outside of the row, the spacing between the trees should be about ten feet apart. On smaller sites, the windbreak may need to be placed closer to the home. Then, the row of evergreens to the west needs to be shortened so no evergreens are south or southwest of any windows.

Increase tree canopy cover in urban neighborhoods

Smaller residential yards just do not have space for large dense evergreen trees whose spread may reach thirty feet. However, remember the canopy of tall trees throughout the neighborhood also provides significant shelter. Imagine what you see of your neighborhood from an airplane: your goal should be to have mature trees covering at least half the surface when seen from above. These can be a variety of trees, placed to the west, north, and east of homes, shading pavement, with as few trees as possible in yards south of homes.

Putting it all together

To have energy-conserving trees in your yard requires taking a careful look at your situation and careful attention to planting and caring for the young trees, as well as preserving large healthy trees.

Identify existing house and yard conditions

- Figure out which side of your house faces north.
- Draw your house on a piece of paper with north facing the top of page. Show on the house drawing the approximate location of east and west-facing windows.
- Draw in the approximate location of the major features of your yard: driveway, property lines, power lines, existing trees.

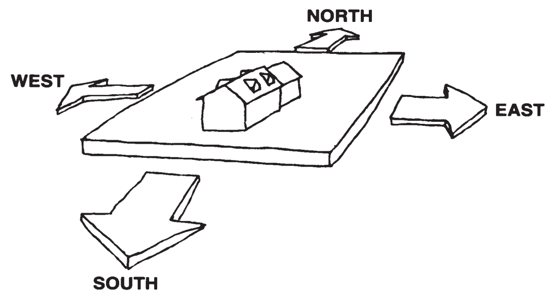
Determine where you need trees for energy conservation

Evaluate where trees will be most beneficial:

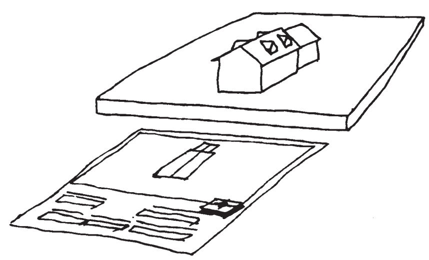
PRIORITIES
- Planting shade trees due west of west-facing windows.
- Planting shade trees due east of east-facing windows.
- Planting an evergreen windbreak tree to the north and west

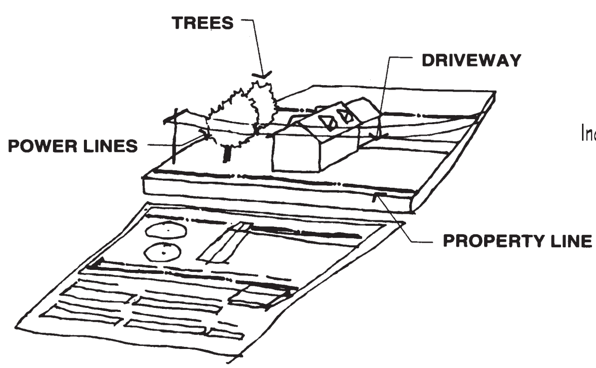
Select and mark your best planting site so that it doesn't conflict with existing trees, wires, etc.

See Diagram 1 to locate appropriate trees. Identify which trees you want to use from the list provided. Make sure the trees selected grow well in your area. Try not to pick trees used often in your neighborhood.

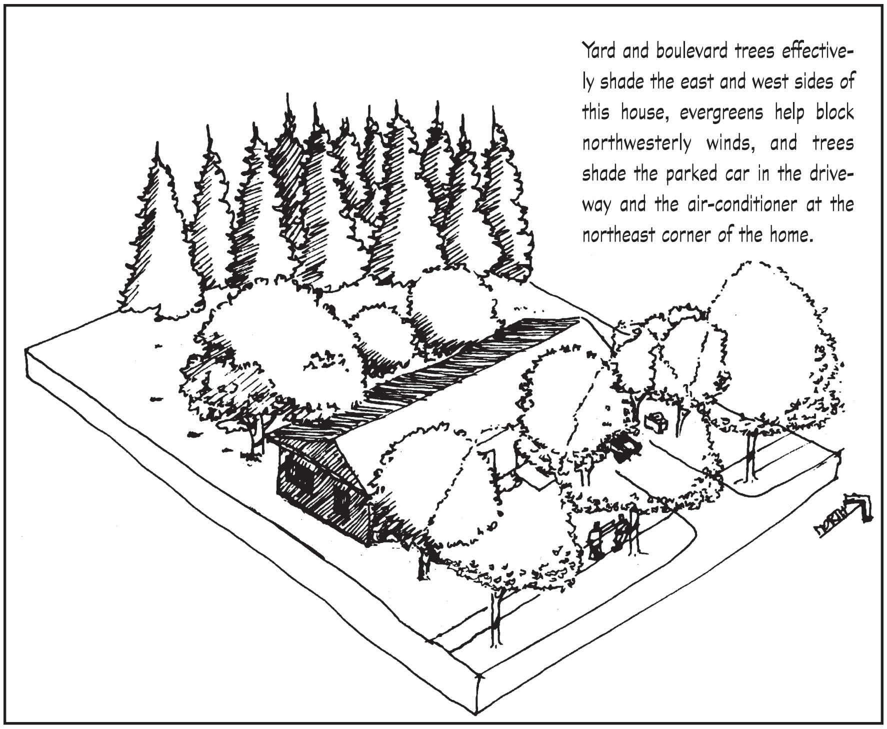


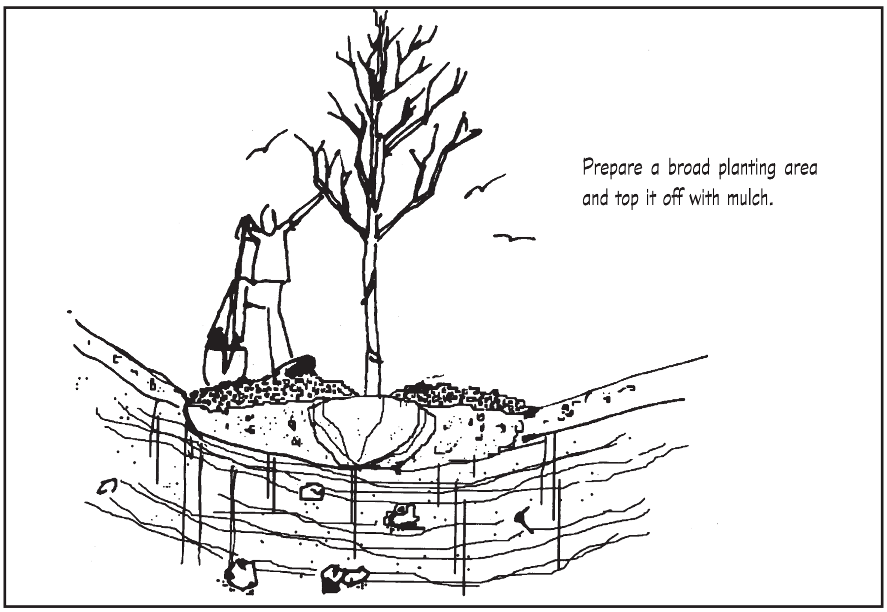
Find north exposure.


Note shadows in your drawing.



Include all major features.





Buy a good tree

Once you have decided on the best location and species of tree, you will want to shop for the best tree. As you look at the tree in the nursery, look for good branching structure and a root system big enough to support the tree. The most cost effective tree will be a smaller, less expensive tree, because with proper care and protection from vandalism, a tree that starts small will reach the beneficial size close to the same time as a tree that started large. For example, good selections would be a container grown evergreen 3 feet tall and a bare root or containerized shade tree with a 1-inch diameter trunk.

Plant it right

Before digging always check for underground and overhead utilities. Trees do better if young roots near the soil surface are given a good place to grow. Dig a broad shallow planting area the depth of the root ball and about five times the width of the root ball. Usually it is best to plant trees using the same soil that came out of the hole. After planting, mulch a large area around the tree. Throughout the growing season, generously soak the whole planting area with water on a weekly basis.

Funding for this project was approved by the Minnesota Legislature as recommended by the Legislative Commission on Minnesota Resources from Oil Overcharge Money.

This brochure was prepared in cooperation by the Minnesota Department of Natural Resources, Division of Forestry; the University of Minnesota; and the Minnesota Department of Public Service. Margaret (Peggy) Sand, author; William W. Weaver, illustrator; Amy Beyer, graphic designer; JoAnne Ray and Chris Gilchrist, editors; Patrick Huelman, technical advisor.

Trees Recommended for Energy Conservation

COMMON NAME	MATURE HEIGHT	DISTANCE FROM HOUSE**	COMMENTS
Recommended shade trees			
Norway Maple	40+'	15-30'	many varieties; either dark green or with red spring color
Red Maple*	40+'	15-30'	red fall color; select northern variety e.g. 'Northwoods'
Sugar Maple*	40+'	15-30'	gold to orange fall color; prefers rich soil
Ohio Buckeye	30'	10-20'	white flower; large nuts; unusual foliage
Horsechestnut	40'	15-25'	white flower; large nut; unusual foliage
European Alder	30+'	10-20'	small nutlets hold over winter
River Birch	30+'	15-25'	reddish peeling bark; needs good soil
Northern Catalpa	40+'	15-25'	large flower, leaves, and pods (native further south)
Hackberry	40+'	15-30'	bumpy bark; very tough once established
White Ash*	40+'	15-25'	such as 'Autumn Blaze' with purple fall color
Manchurian Ash*	40+'	15-25'	easy to grow
Green Ash	40+'	15-25'	only use green ash if a few already exist in the neighborhood
Kentucky Coffeetree*	40'	10-20'	double compound leaves; seed pods
Walnut or Butternut*	40+'	15-30'	has nuts; avoid near vegetable garden
Ironwood	30'	10-20'	smaller version of elm; has hoplike fruit
Amur Corktree	30'	10-25'	corky bark; females have black berries
Robusta Poplar	40++'	15-30'	one of many seedless acceptable cottonwoods; short lived
Black Cherry	40'	15-30'	white flowers; fruit; somewhat scraggly looking with age
Bicolor Oak	40'	15-30'	acorns; more tolerant than most oaks
Littleleaf Linden	40'	15-30'	fragrant June flower; avoid pyramidal-shaped cultivars
American Linden	40+'	15-30'	fragrant June flower; avoid pyramidal-shaped cultivars
Shade trees for use under overhead wires			
Amur Maple	20'	10-20'	red fall color
Serviceberry*	25'	10-20'	spring flowers; berries attract birds
Hawthorn	20'	15-20'	white flowers; red fruit; use thornless variety
Russian Olive	25'	15-20'	silvery foliage; can look scraggly
Flowering Crab	15-25'	10-20'	many varieties available; some have no fruit
American Plum*	20'	10-20'	white flowers; fruit attract birds
Amur Chokecherry	20'	10-20'	bronze bark; white flowers; berries attract birds
Canada Plum*	15'	10-20'	'Princess Kay' with double white flowers; red fruit
Mountain Ash*	25'	15-25'	European, Showy, or Korean; white flowers; red fruit
Japanese Tree Lilac	20'	10-20'	white flowers; seed pods through winter
Recommended windbreak trees (note: avoid placing windbreak trees in the shade of other trees)			
Concolor Fir	40+'	40-80'	blue-gray color; looks like Colorado spruce
Norway Spruce	40+'	40-80'	graceful pendulous branches
Black Hills Spruce	40'	40-80'	dark green; slower growing; drought tolerant
Colorado Spruce	40+'	40-80'	green or blue forms; avoid using too many
Douglas-fir	40+'	40-80'	medium green color; similar to fir and spruce
American Arborvitae	30+'	40-80'	somewhat shade tolerant; avoid dwarf varieties

Note: Pines (Austrian, Red, White Scotch – all 40+') are also appropriate as part of a multi-row windbreak.

* Use only these solar friendly trees near east and west windows.

** Use closer distance for solar friendly shade trees to east and west, for other shade trees use further distance from windows, Evergreens should be no closer than their mature height to east and west windows. DO NOT locate any trees closer to the south windows than TWICE their MATURE height.

HOME ENERGY GUIDE

TECHNIQUES TACTICS & TIPS

Basement Insulation

Minnesota Department of Commerce Energy Information Center

Homes with uninsulated basements can have one-third of their heat lost through the basement floor and walls. Since the earth around the basement is not a good insulator, the concrete itself conducts heat out of the house. This unnecessary heat loss could be costing $150 or more each year. With a one-time cost of around $600 for materials to insulate the foundation of a 1200-square-foot bungalow, your energy savings could pay for the cost of the project in four years. In addition, an insulated basement adds to your living space and will make your entire home more comfortable and evenly heated.

This guide describes two basic methods of insulating basements in existing homes. If you are building a new home or addition, follow the instructions for foundation insulation in our “New Homes” Home Energy Guide, available from our Energy Information Center.

You first need to decide whether to insulate the inside or the outside of the foundation walls, or whether insulating is a good idea at all (in cases of chronic moisture problems, adding insulation is not advised). See the Sidebars comparing the advantages and disadvantages of the interior and exterior methods. Review the pros and cons and decide on the better solution for you. This guide describes both methods, but insulating the interior is the most cost-effective for existing homes.

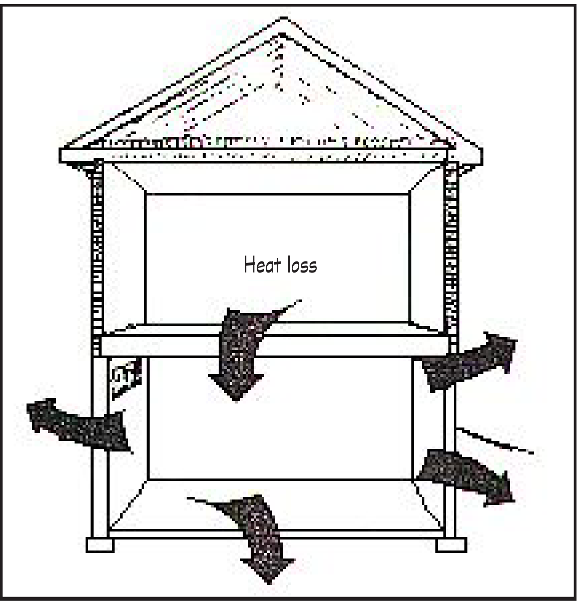
Before you start, familiarize yourself with the basic parts of a foundation wall (see Figure 3). The drawing shows a common construction technique referred to as platform framing, in which the floor joists sit atop a wood plate that in turn rests on the concrete foundation wall..

Interior basement insulation

Starting the job will be easier if the basement is completely unfinished, but chances are, some wall finishing work has been done. If there is no proper air/vapor barrier and little or no insulation, it is best to remove the wall finishes and start over. This will allow you to check for moisture damage as well.

When insulating on the inside, it is recommended that an insulation value of R-13 to R-20 be added to the entire wall for greater energy saving and comfort. There are two ways to do this. The most common method uses wall framing filled with

Figure 1



Related Guides:
Home Insulation
Home Moisture
Indoor Ventilation

What to do before you start

1. Before you insulate, read our Combustion Air Home Energy Guide, available from the Energy Information Center. It may not seem to make sense, but the more you seal up your house against outdoor air leaks the more you need to provide an outdoor air supply for your combustion appliances. **Unless you have a sealed combustion furnace and water heater, you must have an outside air supply near your furnace and other fuel burning appliances.** Having a dedicated combustion air supply provides the right amount of air in the right place, rather than relying on arbitrary air leaks throughout your house. This should be done before your basement is sealed and insulated. Our Combustion Air guide provides "how-to" instructions for installing a combustion air supply.

2. **WARNING: Seal air leaks in any return ducts.** Check to see that ducts or other cavities used as "returns" to your furnace are air tight. Research indicates that leaky returns cause uneven cooling in air conditioned homes and can create a potentially dangerous backdrafting problem with your gas furnace or water heater – possibly leading to elevated levels of carbon monoxide in the house.

3. **Check for water problems before insulating.** Don't attempt to cover up water problems with insulation and wall board. If moisture problems cannot be cured at the source, do not even consider insulating the interior of your basement. (See Capillary Test Sidebar.)

4. **Consult a local building official about codes and requirements.** If you are planning a basement bedroom, you are legally required to have egress windows, which are sized and located to serve as an easy escape route for occupants if needed. Also, visit your city hall or county permit office to obtain any necessary building or remodeling permits.

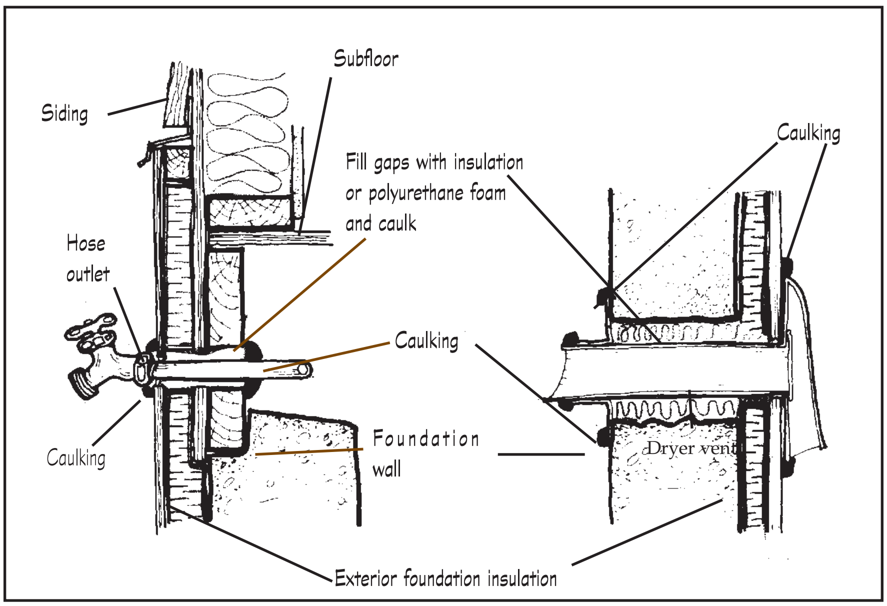


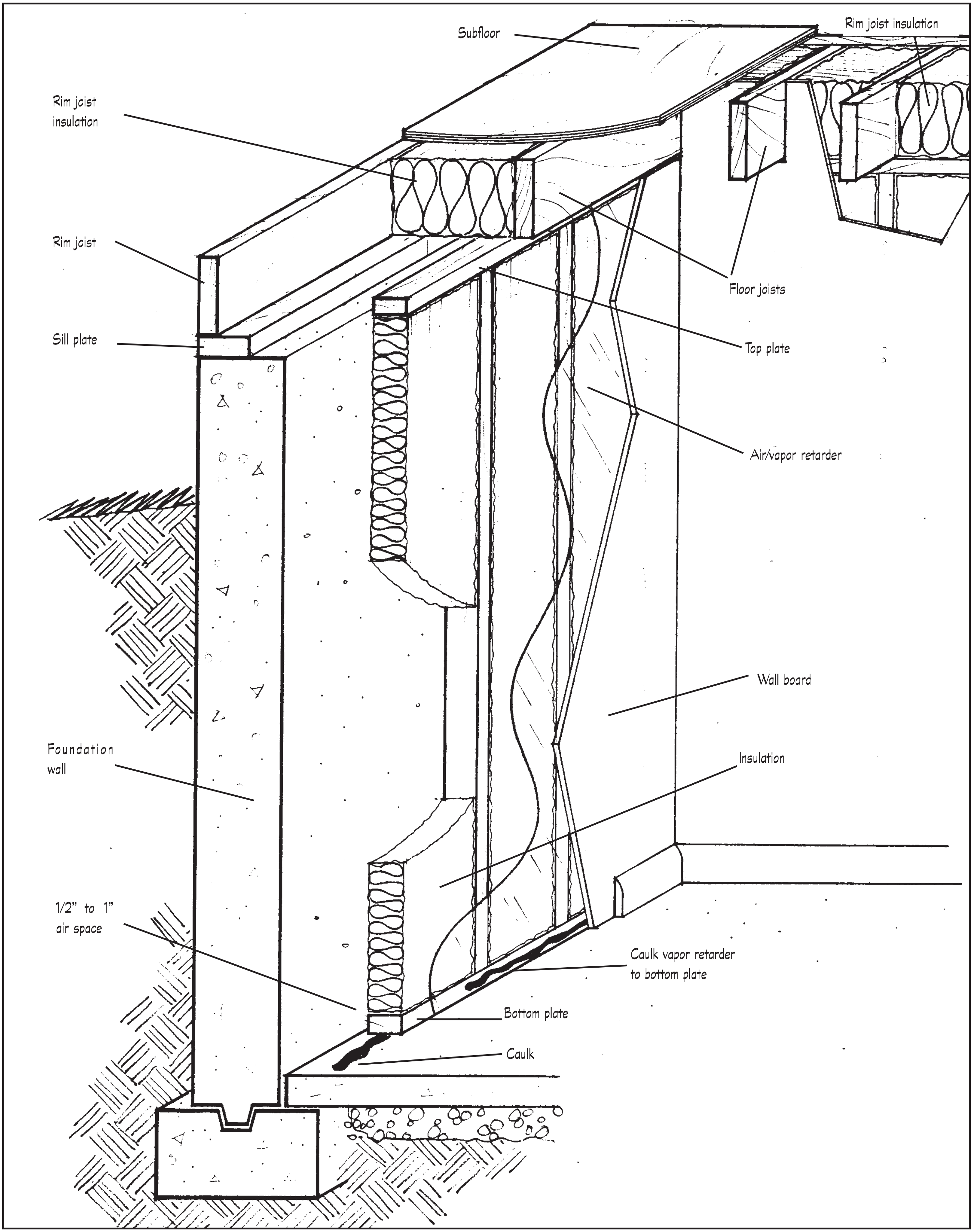
Figure 2
Use foam sealant for large gaps around penetrations in walls or joist areas.

fiberglass batts. This method is described in detail in this guide. The second method involves fastening extruded or expanded polystyrene or polyisocyanurate to the wall. A number of fastening systems can be used in addition to standard framing. Check the insulation manufacturer's literature for the recommended method of application.

Step 1: Seal the air leaks. It is easiest to seal the wall against air leakage before you start framing or applying rigid insulation. Locate and seal any air spaces around service pipes, ducts or conduits that go through the walls or end joists. This will not only stop air and moisture leakage, but will also help keep crawling and flying insects out. Use a good quality butyl or silicon caulk that is compatible with concrete. Call theEnergy Information Center for the Caulking and Weatherstripping Home Energy Guide, which explains types of caulking materials and methods of application. Where there are larger gaps, fill with foam backing rod or polyurethane spray foam (see Figure 2).

For comfort, cost and safety reasons, also make sure that the return air ducts or cavities that return air to your furnace are air tight. During the winter, warm indoor air causes the house to act like a big chimney, drawing air in at the lower parts of the house (slightly depressurizing the basement) and exhausting warm air through the upper levels wherever there is an opening in the wall or ceiling. Leaky returns add another avenue for air to flow out of the basement to the upper floors, strengthening the negative pressure in the basement. Ultimately, this pressure on air supply can cause backdrafting of the furnace and water heater – meaning the combustion gases that normally rise up the flue (including carbon monoxide) are drawn back into the house. Sealing the returns is an important step in avoiding this problem. In the summer, leaky returns allow cooled air to stay in the lower levels, completing a "short circuit" without reaching the upper floors. Difficulty in cooling the upper floors causes the air conditioner to run longer, resulting in high energy costs. Sealing the ducts with mastic or foil backed tape will allow better, more even air distribution and will help your air conditioner run

Figure 3: Interior insulation method



Tips

If you use a moisture barrier, make sure to extend it under the bottom plate.

Keep pipes and drains on the "warm" side of the insulation.

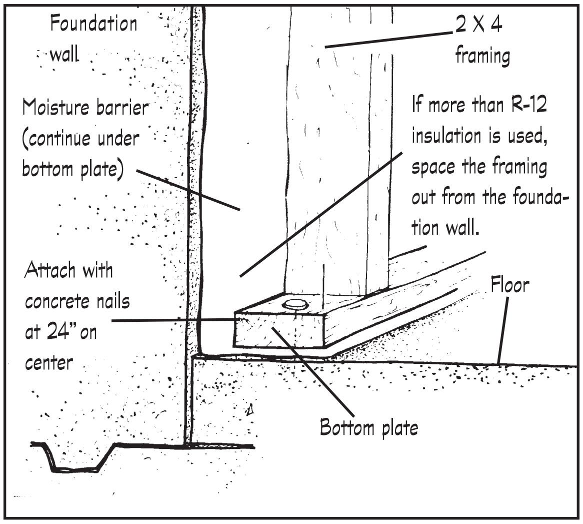


Figure 4

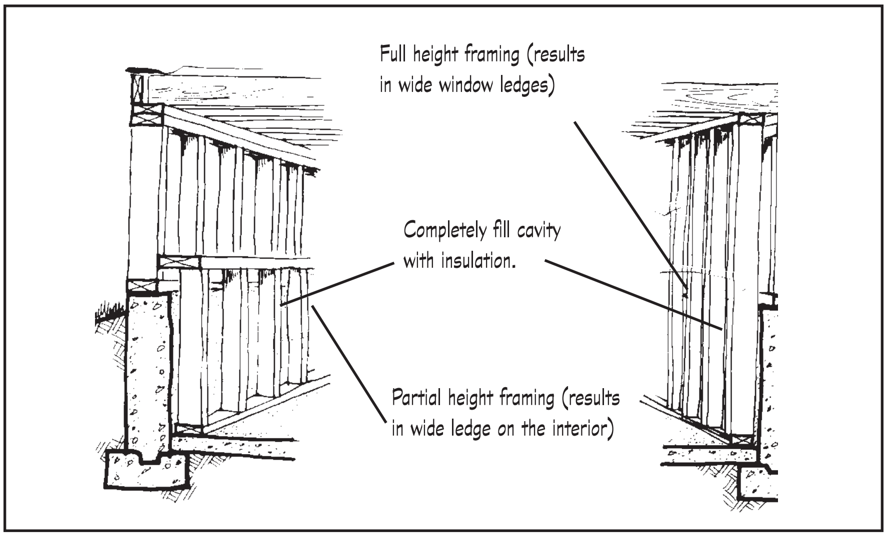


Figure 5
Two framing methods for a bi-level home.

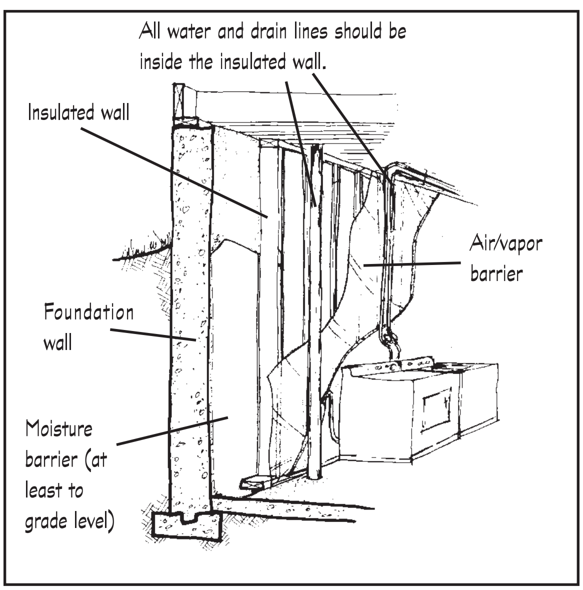


Figure 6

more efficiently. Do not use cloth backed "duct tape" on heating ducts because it will dry out and release over time.

Step 2: Consider installing a moisture barrier – but only if the foundation is dry. Moisture barriers are generally recommended, especially in new homes, to protect the insulation and framing materials from water damage. Also, homes over 10 years old often do not have drain tile at the footings, making the foundation walls and floor prone to moisture problems. If you are sure you have a dry basement, you may skip this step. If you are not sure, use the "Capillary Test" Sidebar to identify problem areas.

A moisture barrier (which functions differently than an air/vapor barrier, but can be the same material) is usually 6 mil polyethylene plastic attached to the bare foundation wall with an adhesive, a wooden batten, or stapled to the back side of the wall framing before the frame is placed against the wall. The moisture barrier can start at the top of the foundation wall or at ground level, but must extend down to the basement floor and under the bottom plate (see Figure 4). The goal is to keep outside moisture away from the insulation.

Step 3: Construct a wall frame. Use wall framing of 2 x 4s at 24 inches on center to provide an insulation cavity, wiring space and support for the interior finish. The interior face of the wall frame can be placed 3 - 1/2 inches from the foundation wall for R-13 batt insulation or 5 - 1/2 inches for R-21 batts. If the foundation wall is uneven, the frame can stand out from the wall. A common technique is to use 2 x 6 plates with 2 x 4 studs, which allows extra space for an uneven wall. An additional one-half to one-inch air space between the frame and the wall is recommended if you are not using a moisture barrier. Use a single top and bottom plate and single members around windows. Always use treated lumber for the bottom plate, and for the stud wall as well if you plan to finish the basement.

Bi-level homes are a special case. Two techniques for framing a bi-level are shown in Figure 5. Framing around stair wells and landings may also pose problems. Another exception is a cold storage room, which does not require framing or insulation on the outside walls, but interior walls need to be insulated from the rest of the basement. Crawlspaces also need to be sealed and insulated properly to avoid basement moisture problems. (Follow the procedure for insulating crawlspaces in the Home Insulation Home Energy Guide.)

Each situation is unique and you may have to improvise. If possible, place the framing behind any pipes or ducts located close to the foundation wall to prevent freezing (see Figure 6). Never leave pipes or drains on the outside, or "cold" side of the insulation layer. Thinner pieces of rigid insulation may be used behind pipes or lines where framing won't fit.

Many plumbing reference books outline simple drainage and water line renovations, if moving them is necessary. Moving electrical panels or gas and water meters requires qualified professionals and may be expensive. Electric panels are still "live" even when the main switch is off. The simplest solution is often to just insulate and frame as closely as possible to the unit. Remember to cover all insulation with drywall.

Step 4: Seal only large holes in the rim joist. Research indicates that over 25 percent of a typical home's air leakage occurs in the rim joist area. While this is clearly too much leakage, some of this air may be needed by your appliances. Reducing air leakage in the lower part of your home without providing sufficient air for combustion and exhaust appliances increases the risk of carbon monoxide exposure in your home. Sealing the rim joist should be considered only when there is a sealed combustion heating system and a sealed combustion water heater. Other fuel burning appliances using wood, propane and fuel oil also need to have a sealed combustion design if you plan to seal the rim joist. These include space heaters, room heaters, gas fireplaces and fireplace inserts.

Over-sealing the rim joist may reduce the air leakage in your home to the point of creating an unhealthy environment; yet, homes with moisture problems may need the rim joist sealed to prevent damage to the building. In that case, a mechanical ventilation system may be needed for acceptable indoor air quality and relief of excess moisture. Our Home Moisture Home Energy Guide will help you solve moisture problems at their source.

In bi-level homes, treat the lower level like a basement, even though it is largely above grade. Seal only the large holes in the rim joist area. On upper levels, regardless of house style, the band joist area should be well sealed.

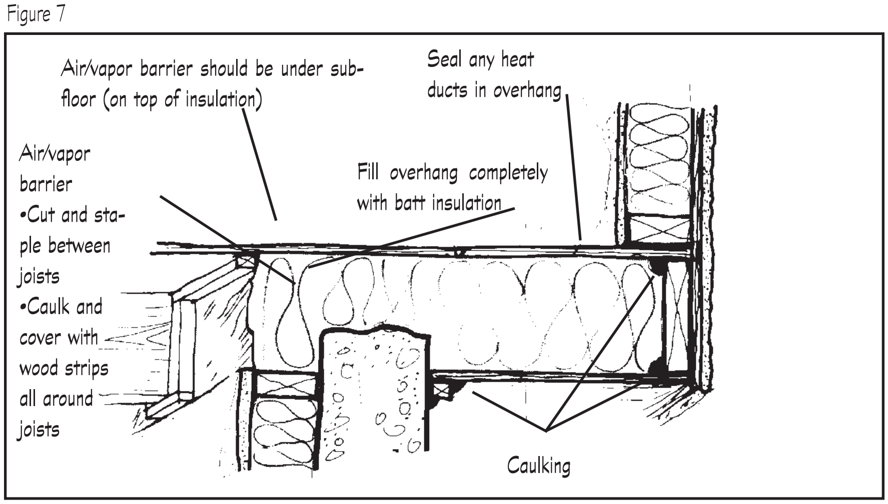
Homes with all electric heating and water heating appliances may have the rim joist sealed without increased risk of carbon monoxide exposure; but they may need a mechanical ventilation system for moisture control and acceptable indoor air quality.

Cantilevered rim joists are another exception to the rule and can usually be sealed without compromising your safety. A simple method is to cut pieces of sheetrock or plasterboard to fit each joist space (the area between the joists, the floor above and the sill plate below.) Then, caulk all the seams to stop water vapor and air leakage.

Step 5: Install insulation on walls (and joist space, if appropriate.) Fiberglass batt insulation is usually used because it is relatively inexpensive and easy to install in vertical spaces. Place insulation in the wall cavities formed by the framing. The stud spaces must be completely filled to prevent air movement behind the insulation, which can result in increased heat loss. Make sure to cut the insulation pieces to exact sizes required. Do not fold or overlap pieces to make them fit.

Insulate the "warm side" of the walls separating a cold storage room from the heated basement. The ceiling of a cold storage room must also be insu-

Figure 7



Tools for the job

Safety and protection equipment such as a hard hat, goggles, gloves and a breathing mask should be used when working with power tools and insulation materials.

Interior method

- Basic carpentry tools
- Sharp knife for cutting insulation batts, rigid insulation, and air/vapor barriers
- Caulking gun, stapler
- Drill, masonry bit and masonry nails

Exterior method

- Shovels, pick and wheelbarrow
- Scraper and stiff brush for cleaning the exposed foundation wall
- Short bristle paint brush for applying water-proofing material
- Basic carpentry tools
- Drill, concrete bit, masonry nails or anchors if attachment to concrete is required

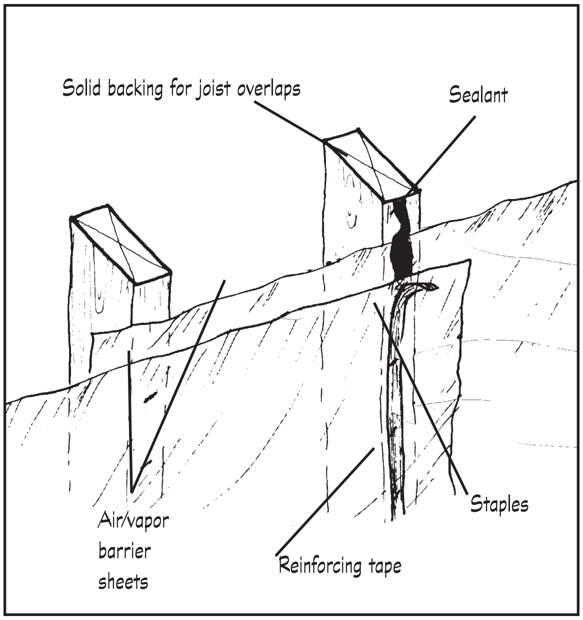


Figure 8
Overlap the air/vapor barrier at least one joist or stud space. (Insulation is not shown.)

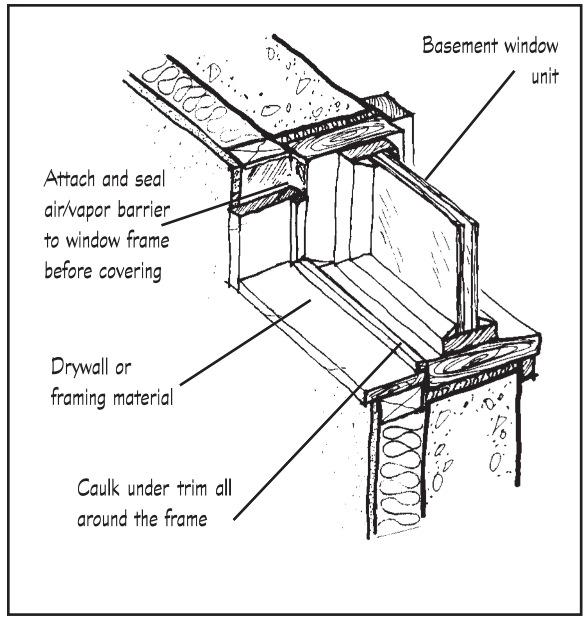


Figure 9
Seal around window and door openings.

lated in order to warm the floor above. If your home has bow windows or bi-level construction, seal the floor overhangs well and insulate as shown in Figure 7.

Before proceeding, check the insulation you have installed to make sure all areas have been filled and make sure no pipes or ducts have been covered by the insulation.

Step 6: Apply the air/vapor barrier. Also called an air/vapor "retarder," it is essential to add this layer of protection on the inner or "warm" side of the insulation. This barrier can be provided by 4 or 6 mil polyethylene. Staple the polyethylene to the framing, using only enough staples to hold the material in place. Do not pull it tight. All seams should overlap one joist or stud space (see Figure 8). Better contractors use acoustical sealant (a caulk and glue mixture) to seal the barrier against air leakage. Overlaps, joints or edges can be reinforced with a strong tape (do not use cloth backed duct tape) before stapling. The barrier should also be sealed around windows and exterior door openings as shown in Figure 9.

It is important to create as complete an air/vapor barrier as possible between the inside and outside. Make sure you do not accidentally puncture the barrier. Repair any tears or holes in the polyethylene before covering with plaster or drywall.

Moisture problems: Symptoms and solutions

Moisture problems may or may not be obvious. Fungus and mildew on the cement block, or cracked and bulging foundation walls are sure signs of moisture. Feel the surface of the wall and look for a powder-like "efflorescence" on the wall, indicating the remains of excess moisture. If the basement is finished, you might see brown water marks on the sheetrock or paneling, or rust on the bottom of the furnace or boiler. You can test for moisture by following the "Capillary Test."

Moisture problems must be solved at their source before you insulate your basement. The first place to look is outside, around the foundation (see Figure 10). Are your rain gutters and downspouts cleaned out and positioned to keep water away from the foundation? Downspouts should lead water at least 10 feet away from the house. Also, make sure the ground slopes away from the foundation (even if you have to add a truckload of dirt around the perimeter of your house) and make sure that sidewalks, driveways or a neighbor's downspouts are not directing run-off toward your house. If exterior control methods are ineffective, you may need to hire a contractor to install drain tile at the foundation footings. In that case, you may want to insulate the exterior rather than the interior.

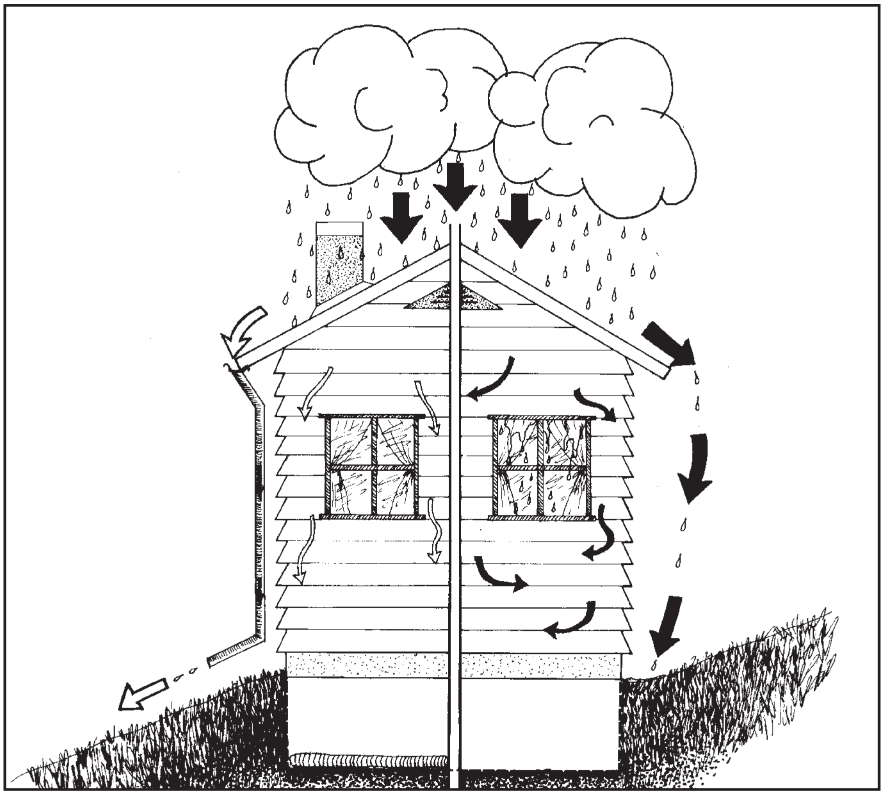


Figure 10
Gutters, a slope away from the house, and drainage tile in the foundation keep the left side of this house dry. No gutters, a slope toward the house, and no drainage tile expose the right side to moisture damage.

Waterproof paint, by itself, is not an effective remedy against moisture problems. After resolving outside sources of the problem, then you can benefit from applying waterproof paint before insulating and finishing the inside.

Exterior basement insulation

Insulating a basement from the outside may be the logical choice for newer homes where the landscaping is not completed, or if the exterior foundation wall needs repair. General directions for installing exterior insulation are described here, but you should always consult the insulation manufacturer's literature for specific installation techniques.

Insulating the exterior involves digging around your foundation. In all cases, before you begin you must mark the location and depth of utility services such as electrical lines, gas pipes, as well as telephone and cable TV hook-ups. In Minnesota you can call one number to check the location of all utility lines on your property. Call Gopher State One at 454-0002 in the Twin Cities metro area, or from Greater Minnesota, call toll-free 1-800-252-1166.

The most practical way for the do-it-yourselfer to insulate the exterior is the "apron" method, as shown in Figure 11. This is a partial depth method, where insulation is placed against the wall to extend 12 inches below ground and a second piece is placed horizontally to extend about two feet out from the bottom of the vertical piece. Above ground, it is best if the insulation extends high enough to cover the rim joists, but since it is often difficult to remove existing siding, you can place the insulation up to the bottom edge of the siding, then insulate the rim joist area from the inside. This method will effectively reduce most of the heat loss from your foundation.

Insulating down the entire wall to the footings is another method, but it is difficult and probably not cost-effective unless you have to dig down for another reason, such as adding drain tile. This method requires a professional building contractor.

Step 1: Prepare the wall. Begin by digging a trench about 18 inches deep around the foundation. Clean the newly exposed wall area of dirt or other debris with a brush or scraper. If the black damp-proofing is dry, cracked or missing, repair

Capillary Test

To determine if moisture is coming through the foundation walls or floor to the inside, or whether moisture is coming from inside the house itself, do the following simple test:

1. Identify the damp interior surface. Testing multiple locations on the floor and walls may be necessary to locate external sources of moisture.
2. Dry a portion of the damp area, at least 2' by 2', using a hair dryer. (Testing larger 10' areas is suggested.)
3. Cover the dried area with an air/vapor barrier, preferably polyethylene, firmly attached and sealed with tape around the edges.
4. Check the underside of the barrier after a couple of days.
   - If there are beads of moisture under the plastic, there is water seeping or wicking into the house.
   - If the plastic is wet on the room side and dry underneath, the dampness is from an inside source of moisture.
   - If both sides are damp, it indicates both external and internal condensation problems.
5. Leave the plastic in place for up to two months to test the basement under a variety of conditions.
6. Consult a professional if the the test is hard to interpret. Seasonal variations in water flow patterns and the ground water table can lead to confusing results.

Tip

Because insulating the exterior is more expensive and difficult than insulating on the inside, it is probably a cost-effective option only if you have to dig around the foundation for other reasons, such as making repairs, adding drainage or solving an exterior moisture problem."

— Energy Information Center

the affected area. Building supply stores carry bituminous coatings for this purpose that can be brushed on by the homeowner. Be sure to follow the manufacturer's instructions carefully and allow any new damp-proof coatings to dry completely before applying insulation.

Inspect all wall penetrations and surface mounted fixtures such as exterior taps, exhaust vents, electrical outlets, hose bibs and gas lines. These should be sealed to the foundation wall with a waterproof putty, grout or silicone sealant. If possible, extend fixtures out from the wall to accommodate the insulation. Hire a qualified contractor to move gas or electrical fixtures.

Step 2: Install flashing. Loosen the lower edge of the siding or stucco and building paper. Leave the siding pulled away about one-fourth inch from the wall so that a flashing (also called drip cap or J-channel) can be installed beneath it. The flashing allows the insulation to extend beyond the line of the siding or stucco and protects the insulation and foundation from rain. The flashing should be wide enough to cover the thickness of both the insulation and protective covering.

Slide the flashing into place under the existing siding or stucco and building paper before you install the wall insulation. There are many details necessary for a good installation. Refer to a good general construction or remodeling manual (check your public library) for details appropriate for your home.

Step 3: Install wall insulation. There is a variety of materials that can be used for exterior insulation. Common materials include: extruded and expanded polystyrene, foil-faced polyisocyanurate, and rigid fiberglass. High density expanded polystyrene can also be used and is the least expensive, but is not reported to perform as well as the other three options. Before using a low-density type, such as beadboard, verify the suitability of the product for underground use. Materials not tested and approved are known to decompose underground. Extruded polystyrene can be used underground both vertically and horizontally, as needed for the apron method. Rigid fiberglass and polyisocyanurate can only be used vertically against the wall, not for the horizontal apron piece. Whatever product you choose, plan to insulate to a minimum of R-10.

The recommended method for applying and fastening insulation to basement walls depends on the type and thickness of the insulation and the soil conditions. If a product is sold for below-grade use, the manufacturer must provide information on methods of application.

If the backfill is heavy clay, or other non-porous soil, attach a "ledge" of pressure treated lumber to the foundation wall at the bottom of the vertical insulation to help keep the insulation board in place.

Step 4: Install a protective wall covering. The insulation must be protected to avoid physical damage from lawn mowers or garden tools. In addition, all rigid insulation materials must be protected from direct exposure to sunlight. A number of materials can provide this protective covering: exterior grade plywood, stucco, cement, brick or treated siding.

Stucco or siding is often used because it is easy to color these materials to match your home. Stucco can be applied over a wire lath which can be attached directly to the rigid insulation. Wear hand and eye protection when working with wire. (Some new stucco products do not require the use of a wire lath.) Check with the product manufacturer for exact wall preparation requirements.

Siding material such as exterior grade plywood can be applied over rigid insulation with a variety of fasteners. The protective coating should reach at least 9 inches below ground level.

Step 5: Backfill. When the siding, insulation and flashing are all in place you can back fill with soil. You may have to add extra soil around the foundation to achieve a sufficient slope away from the house. A 1-inch drop for every 18 inches of travel is recommended to ensure proper run-off of rain water. Make a point to talk to your contractor about being careful not to damage the insulation while backfilling.

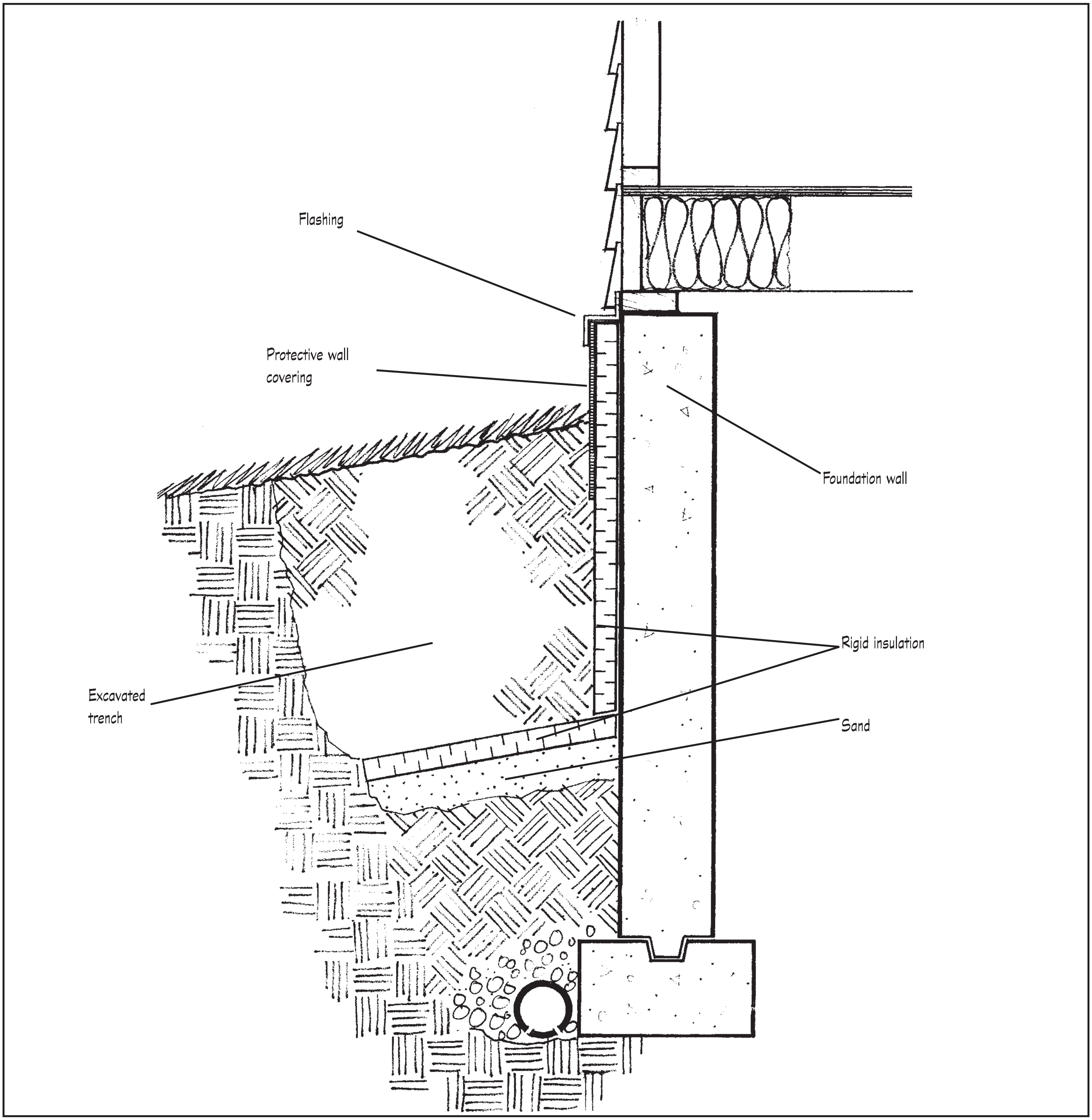


Figure 11
Exterior "Apron" method

Should I Insulate Basement Floor on Inside?

Interior advantages

- Results in a level wall surface for easy finishing
- Work can be done in any weather
- Wiring and plumbing space provided
- Good air/vapor barrier can be installed
- No disturbance of landscaping
- Adds to your living space
- Can be an on-going project (although, don't leave insulation exposed for any length of time. It must be covered with flame retardant drywall as soon as possible after installation.)

Interior disadvantages

- Existing interior finishing may have to be removed
- Difficult if many ducts and pipes are against the wall
- Insulation must be behind water lines to avoid freezing
- Loss of usable living space during construction period.
- Must install egress windows if you are adding a sleeping room in the basement

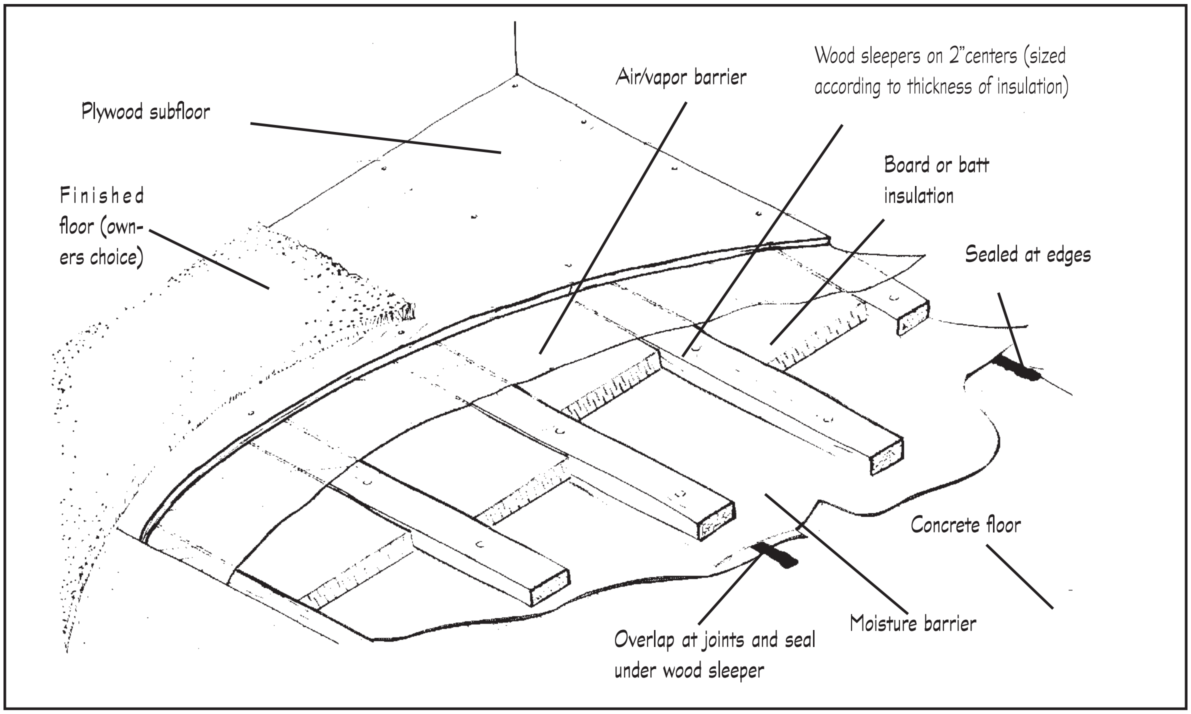
Insulating the basement floor

Although basement floor insulation is hard to justify from an energy savings point of view, it can increase the comfort level considerably. Simply installing carpet over the cement slab will provide a minimum level of thermal comfort, but is also vulnerable to mold and mildew. A more effective method is to build a "sleeper floor," using similar steps and materials used to insulate interior basement walls. (See Figure 12.)

A word of caution: make sure that your basement is dry before insulating the floor. Check for moisture by doing the "capillary test" described in the Sidebar. If a damp spot occurs within 24 hours of applying the test sheet of polyethylene, the floor is too moist. Do not insulate until the moisture problem is corrected. Also, avoid insulating the floor in areas where shifting or swelling soil might lift the basement floor.

To insulate a concrete floor, first place a polyethylene moisture barrier on the concrete to prevent the transfer of moisture to the sub-floor. Frame and insulate the sub-floor with batts or rigid board insulation, following a similar process as when insulating an interior foundation wall. Apply an air/vapor barrier, then install plywood sheeting or other sub-floor material, and finish with your choice of floor covering.

Figure 12
Building a sleeper floor helps assure warmth and comfort.



Summary of insulation methods

Before you start:

- Make sure you have a combustion air supply for your gas or oil furnace, boiler and water heater. Sealing and insulating your basement can have a major effect on the fresh air supply needed by all fuel burning appliances. Call the Energy Information Center for the Combustion Air Home Energy Guide.
- Seal any leaks in the duct work that carries return air to the furnace. Leaky ducts can cause your furnace or water heater to backdraft dangerous combustion gases.
- Evaluate moisture conditions in the basement. Do not install interior insulation until moisture problems are corrected.
- Check your gutters, downspouts and landscaping around the foundation to make sure rain water is properly draining away from your house.
- Choose between exterior or interior basement insulation. Then decide on materials to use, including existing materials that can be salvaged.
- Measure your requirements and obtain cost estimates from suppliers or contractors. Ask to see manufacturer's literature on the insulation you purchase.
- Check on low-interest loans that may be available for home energy improvements. Call the Energy Information Center to find out about current funding sources.
- Obtain permits from your city officials before remodeling your house or its electrical system.

For the interior method:

- Seal air leaks in walls and some joist areas. (Don't over-seal the rim joist area.)
- Apply a moisture barrier only if the basement is dry.
- Frame the wall and make any required electrical, plumbing or heating changes.
- Apply insulation to the wall.
- Apply air/vapor barrier.
- Finish walls, ceilings and window casings.
- Install egress windows in areas intended for sleeping.

For the exterior method:

- Excavate around the foundation and clean the wall of dirt and debris.
- Loosen siding or stucco to install flashing.
- Insulate wall by selected method.
- Apply a protective covering to the insulation and backfill excavation carefully.
- Nail down siding and flashing.

Should I Insulate Basement Floor on Outside?

Exterior advantages

- No disturbance of previous interior work
- Interior water lines protected
- No loss of living space during the project
- Any cracks or leaks in the foundation can be repaired
- Certain insulating materials will act as an additional moisture barrier, depending on application
- A good option if indoor moisture problems prohibit interior insulation

Exterior disadvantages

- Requires extensive digging which can be physically demanding
- May be difficult or impossible to do near patios, steps, or deck
- Disturbs existing landscaping
- Must be completed quickly to avoid flooding if it rains
- Must be completed in warm weather
- Generally uses more expensive materials
- Not advisable in extreme southern Minnesota because of termites
- Protective coating is subject to damage

HOME ENERGY GUIDE

TECHNIQUES TACTICS & TIPS

Windows & Doors

Minnesota Department of Commerce Energy Information Center

Shopping for windows and doors can be confusing if you are not familiar with the new technology available in today's marketplace. This guide helps you understand your options and how your choices can affect your comfort and energy costs. This guide also provides tips on installing and repairing windows and doors, and it explains the terminology that will help you ask the right questions before you make a purchase. Becoming an educated shopper will allow you to choose the features your home needs, without paying for more than you need.

Energy efficient windows: what to look for

Traditionally, windows and doors have been a weak energy link in home construction, often accounting for 35 to 40 percent of a home's heat loss; but new technology has greatly improved the energy efficiency of today's products. The three key elements of efficient windows are: the insulating quality of window materials, the air tightness of the window assembly, and the proper installation techniques.

Look for the following options when you are window shopping:

Low U-value. The total unit U-value indicates the efficiency of the entire window assembly. Total unit U-value offers the best measure of efficiency for windows. Look for a U-value of 0.35 or less when shopping for windows. (For more information, see sidebar "Understanding the Standards.")

If this important measure of efficiency is not stated on window labels, ask the sales representative for the product test data.

Multiple glazings. The more panes (or glazings), the better the insulating quality of the window. Most manufacturers use a combination of layers, substituting thin plastic sheets for the internal panes of glass. The result is a lighter weight window with the same insulating ability and clarity of the all-glass versions.

Gas-filling. The air space between the glazings adds to the window's insulating quality. The efficiency increases even more if the space is filled with gas (such as argon or krypton) which is a better insulator than air.

Low-e coatings. Adding a metallic coating on one or more panes of glass (usually on inside layers) lowers the window's ability to transfer heat, thereby saving energy. The term "low-e" is actually a trade name indicating one of many low emissive coatings. The difference between a hard or soft coating is its durability and level of emissivity (usually from 0.4 to 0.1); one type isn't necessarily better than the other. When you purchase a low-e window, ask for the emissivity level and choose the lowest number.

Insulating spacer. Recent studies show that the material used to "space" the glazings affects a window's efficiency to some degree, but has a greater impact on its tendency to have condensation problems. The traditional aluminum spacers are excellent conductors, but terrible insulators, so look for windows with non-metal, insulating spacers instead. The primary benefit is reducing the

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Door & Window Recommendations

For windows:

U-value
= 0.35 or less

Low-e rating
= 0.2 or less

CFM = 0.1 or less

Shading coefficient
= 0.5 to 0.3

For doors:

R-value = 8 or more

CFM = 0.2 or less

Understanding the Standards

Shopping for windows and doors can be a bewildering experience for the consumer unfamiliar with the technology and the vocabulary. Following is an explanation of the most common terms and numbers used to describe the energy efficiency of windows and doors.

R-value and U-value are the two common measures used to rate how well a specific material or system resists or conducts heat flow. R-value measures the resistance to heat flow. The higher the number the better the insulating quality. In general, R-value refers to the insulating quality of a specific part of the door or window (e.g the frame or center of glass).

U-value measures the ability of a material or system to conduct the flow of heat. The lower the number, the better its insulation ability. U-values most often refer to the quality of the entire system (the glass, the frame, the spacer combined). Therefore, it is most valuable to compare U-values when shopping for windows. R-values are most often used to compare doors since there are fewer components.

Keep in mind that the higher the R-value the better the insulating quality, and the lower the U–value the better the insulating quality. For perspective, consider that a wall in a typical new home in Minnesota has an insulating value of approximately R-20, while a single pane of glass has an insulating value of less than R-1. When discussing R- or U-values with a salesperson, ask the following questions:

- Does the stated R- or U-value apply to the entire unit (including the window edge and frame) or to the center of glass only?
- Are the U-values determined by National Fenestration Rating Council (NFRC) standard? If not, the numbers may not be as reliable.

Air infiltration rate is an important measure of how well windows will protect the home from unwanted heat loss (or gain). Air tightness is measured in the number of “cubic feet of air per minute” (cfm) that escapes through each square foot of the window‘s “sash crack” under standard conditions. A national standard test is used whereby windows are subjected to the equivalent of a 25 mile-per-hour wind. In this case, the lower the cfm rating, the more air tight the window. This test does not measure the significant amount of air leakage between the window frame and the rough opening in the wall. Air tightness in this area will depend on the quality of installation and caulking or foam seal.

Emissivity describes how well the surface of the glass radiates heat. The lower the emissivity, the less heat is allowed to pass through and the better the energy savings. Low-e coatings, which are ultra thin layers of metallic compounds that are applied to the surface of a pane of glass, are very effective at reducing summer heat gain and winter heat loss.

Shading coefficient measures a window’s ability to reduce heat gain by blocking the heat producing rays. A high shading coefficient will allow more sunlight, and warmth, into the house. A low shading coefficient will block more sunlight to reduce summer heat gain.

Scale of Common U-Values

1.1	0.6	0.5	0.4	0.3
single pane of glass	double-glazed aluminum frame w/ thermal break	double-glazed clear glass, wood or vinyl frame	double-glazed low-e wood or vinyl frame	triple-glazed low-e argon gas filled

likelihood of condensation at the edge of the glazing that can damage frames and sills, causing more maintenance and expense.

Quality sashes and frames. Although not the most important part of a window in terms of energy efficiency, the sash and frame material affects efficiency and is reflected in the total unit U-value. The two important questions to ask are: Is the material a good insulator? and how resistant is it to expanding and contracting with changes in temperature?

Solid steel and aluminum are the least effective because, although durable, they are poor insulators and tend to expand and contract more than any other material. If you choose a window with a metal frame, it is imperative that it have a quality "thermal break" to combat heat loss. A thermal break is a section of material - usually polyurethane or wood - that is sandwiched between the frame parts.

Wood is the traditional frame material because it is a good insulator. Wood frames also expand and contract less than most other materials, but require more maintenance and are susceptible to moisture damage. Wood components treated with a preservative or clad with metal or vinyl offer the benefits of low maintenance and higher insulating value.

Vinyl frames are nearly maintenance free and are similar to wood in insulating quality. However, if you select vinyl windows, you should ask for a guarantee against sun damage, peeling, warping, or discoloration. Also, like metal, vinyl expands and contracts with temperature changes.

Fiberglass frames, or vinyl with a core of fiberglass insulation, are new on the market and offer high insulating quality as well as low susceptibility to expansion.

Quality weatherstripping is a major factor in determining a window's air tightness. Before purchasing a window, check two important points: Is the weatherstripping material durable and is it easily replaceable? For instance, polyurethane, neoprene, and EPDM rubber are durable because they remain flexible under temperature extremes, helping provide a tight seal demanded by our northern climate. Second, since all weatherstripping will eventually show wear, it should be easily replaceable. Ask the sales representative to show you how it can be removed and replaced.

Window installation

Quality installation is essential if you are to get the full benefits of efficient windows. Even the highest quality window will be greatly diminished in energy efficiency if you allow heavy air infiltration between the rough framing and the window. And simply stuffing fiberglass insulation into this area is not adequate. We recommend the following measures for eliminating the gap between the rough opening and the window.

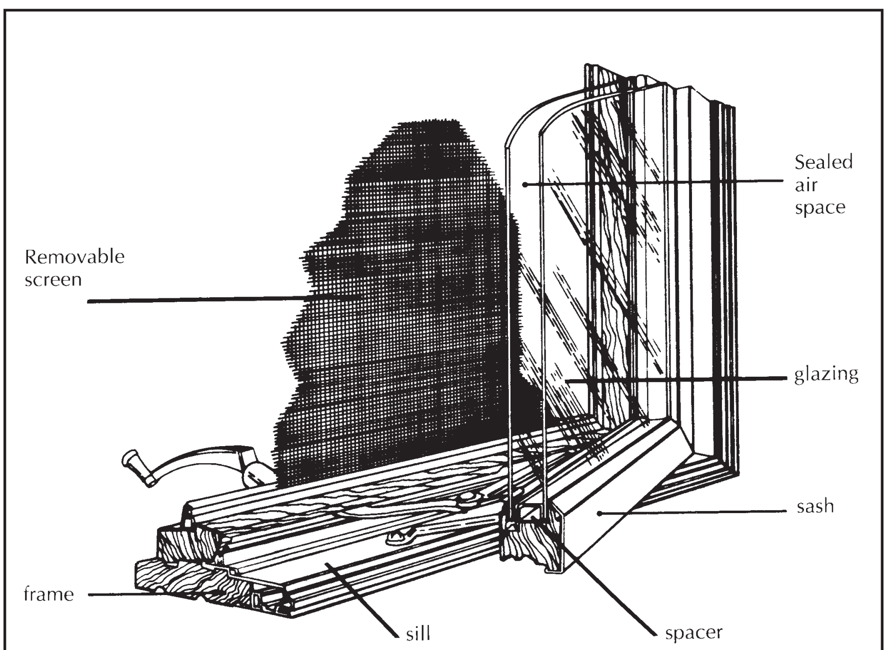
In new construction, make sure the builder sizes the rough opening large enough to allow for installing a good, airtight seal between the window frame and the rough opening. An installation clearance of at least 3/4 inch is recommended. It is critical to follow the manufacturer's instructions.

If your home has a plastic air-vapor retarder, it can be sealed to the window frame. If your home does not have an air-vapor retarder, or if it cannot be reached without removing part of the wall, the gap between the window and rough opening can be sealed with non-expanding foam, or with preformed foam rods and sheathing tape.

Caution

Houses built before 1978 may contain lead-based paint. The older a house is, the more likely it is to have high concentrations of lead in paint. If you work on windows that have painted trim, you need to control any dust and chips and dispose of them safely. Intact paint should not be removed. Pregnant women and small children should stay away from the area until it is cleaned. Information on lead is available from the MN Department of Health, 651-215-0890.

Figure 1
Sealed air space, double glazing, and insulating spacer are among the features of an energy efficient window.



Skylights

Skylights are popular because of the extra light and aesthetic appeal they bring to the home. Unfortunately, their roof location makes them a potential source of serious moisture problems, air leaks, and heat loss or gain. Extra care must be taken to install the skylight so that it is sealed tightly to the air-vapor retarder. Also, in cases where the skylight tunnels through the attic, make sure the builder insulates correctly – – this may be forgotten!

Look for skylights with an overall U-value of 0.6 or less, double-glazing with argon gas fill, a low-emissive coating, and a shading coefficient of 0.4 or less.

If you are planning new construction, find out what technique your builder uses to ensure a tight seal when installing windows and doors.

Storm windows and other options

Before multiple glazed windows became common, storm windows were necessary to protect the typical single-pane prime window, to cut down on drafts, and to add another layer of insulation during the winter months. In newer homes, storms may not be as critical, but for any home with single-glazed prime windows, storms continue to be absolutely essential.

Exterior storm windows can be either a “fixed sash unit,” which is taken down in the summer and replaced with fixed-sash screens, or the more contemporary metal, wood, or vinyl combination storm and screen which does not need to be taken down and stored each season. When installing combination storms, it is important to set the window in a bead of long-life caulk (silicone, butyl rubber, or polyurethane), but be sure to leave weep holes in the caulk to allow moisture to escape.

Interior storms may be suitable as a solution for one or two problem windows (excessively leaky or prone to condensation), but are not generally recommended for use throughout the house. They can be effective if they are designed well and installed very carefully, but poor design or installation can do more harm than good. Interior storms can permit moisture to accumulate between the interior storm and the prime window, creating moisture damage and reduced visibility.

Plastic film can be used as a short-term solution to augment or replace traditional storm windows. It can be applied inside or out, depending on the desired effect. On the outside it helps reduce air infiltration, but it may frost over, reducing visibility as well as creating moisture problems between the storm and the prime window. On the inside, shrink-wrap plastic can help stop heat loss through north-facing or other problem windows, such as those with condensation problems. Shrink wrap is not very durable, however, and it prevents opening the window for quick ventilation.

It is also important to remember that plastic film can be too effective! Although it will reduce condensation on windows, it will also reduce or practically eliminate leakage at windows and patio doors. As a consequence, less fresh air will come into the living space, indoor air quality may be compromised, and the safe operation of furnaces, water heaters, and other fuel-burning appliances may be affected. Overall relative humidity of the indoor air also will increase, leading to possible moisture damage elsewhere in the home. Keep in mind that if condensation occurs throughout the house, or in certain large areas, you should treat the source of the moisture problem rather than treating the windows.

Window condensation: causes and cures

Condensation is not necessarily an indication that your windows are bad and need to be replaced. Condensation will occur whenever the window surface is cool enough to allow moisture in the air to condense on it, which is why some condensation can be expected in the winter. Condensation should be controlled as much as possible, however, since it can damage the window’s components. For instance, moisture on the inside of the storm window indicates that the prime window is allowing air (carrying moisture) to leak out to the storm window where it condenses. Stopping these air leaks with caulking and weatherstripping will stop the condensation and ultimately save your windows. However, it is important to understand that condensation on windows can occur for a number of reasons. Before you replace your windows, call the Energy Information Center for advice.

Improving your existing windows

If you are looking for ways to improve the performance of your existing windows, significant energy savings can be achieved simply by caulking, weatherstripping, replacing a sash, or re-glazing old windows. (See “Combustion Air Caution” sidebar.)

Installing weatherstripping. Loose fitting windows are a major source of air leaks. Installing weatherstripping closes the gaps between the window sash and frame on vertically and horizontally sliding windows and casement windows. The area where the two sashes meet in the center of a double hung (vertically sliding) window also should be weatherstripped. A basic rule is to use weatherstripping in junctures of surfaces that move or slide together and to use caulk on the non-moving parts.

Applying caulk on the inside, where the window frame meets the wall, seals another potential source of air leaks. Caulk can also be applied between the frame and sash on permanent non-sliding sections. Although exterior caulking is important for weatherproofing, it does little to save energy. (Tip: If you have a newer home with vinyl or aluminum siding, exterior foam caulk is the only kind that will stick.) Interior caulking at window and door penetrations, on the other hand, can have a major effect on energy use and household comfort. (Call the Energy Information Center for more details on caulking and weatherstripping.)

Replacing sashes or reglazing a window are alternatives to replacing an entire window. Make sure to choose a sash material with a high insulating value and gas filled glazings with a low emissive coating. For window repair, check with lumber yards that provide millwork services.

Other energy saving window treatments

Outdoor awnings. Another technique to enhance summertime cooling is to install outdoor awnings, which can reduce heat gain through the window by as much as 90 percent while still letting in light. It is important, however, to size them correctly so they will not interfere with winter solar heat gain.

Follow this rule of thumb to determine how far the overhang should extend out from the window: At 44° latitude (southern Minnesota) divide the height of the window (in inches) by 2.7. For instance, if your window is 3 feet high, the awning should extend 13 inches out (36 inches ÷ 2.7 = 13.3). In northern Minnesota, at 48° latitude, divide the window height by 2.2.

Indoor window coverings can also reduce solar gain in the summer. However, specially designed energy efficient window coverings are not considered as important for saving energy in the winter as they were a few years ago, so this is no longer a suggested technique. Also, any window or frame damage that occurs because of applied window coverings (including interior storms) can void any warranty on your windows.

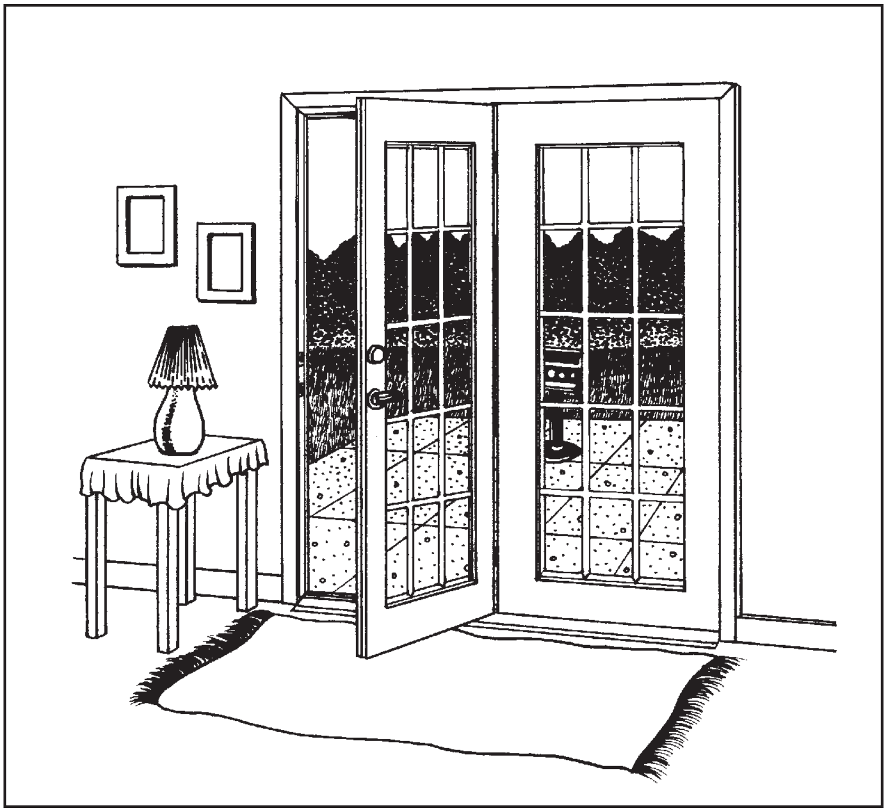


Figure 2
Above: terrace-style doors allow less air leakage than sliding patio doors.

When window condensation occurs

Outdoor temperature (F°)	30°	20°	10°	0°	-10°
Indoor humidity (%) at which condensation occurs	(Average indoor humidity = 30 to 35%)				
*Insulated glass - double					
center of glass	57%	50%	44%	39%	35%
edge of glass	47%	39%	33%	22%	17%
*Insulated glass - double, low-e w/argon					
center of glass	74%	70%	65%	61%	57%
edge of glass	50%	43%	36%	30%	26%

* Assumptions: wood frame, aluminum spacer, 3/8" air space, emissivity of .08

From: Patrick Huelman and Timothy Larson, "Performance of Window Systems in Cold Climates; " Building Solutions 1993 EEBA/NESEA Conference, Vol.1, Energy Efficient Building Association, Wausau, WI, 1993.

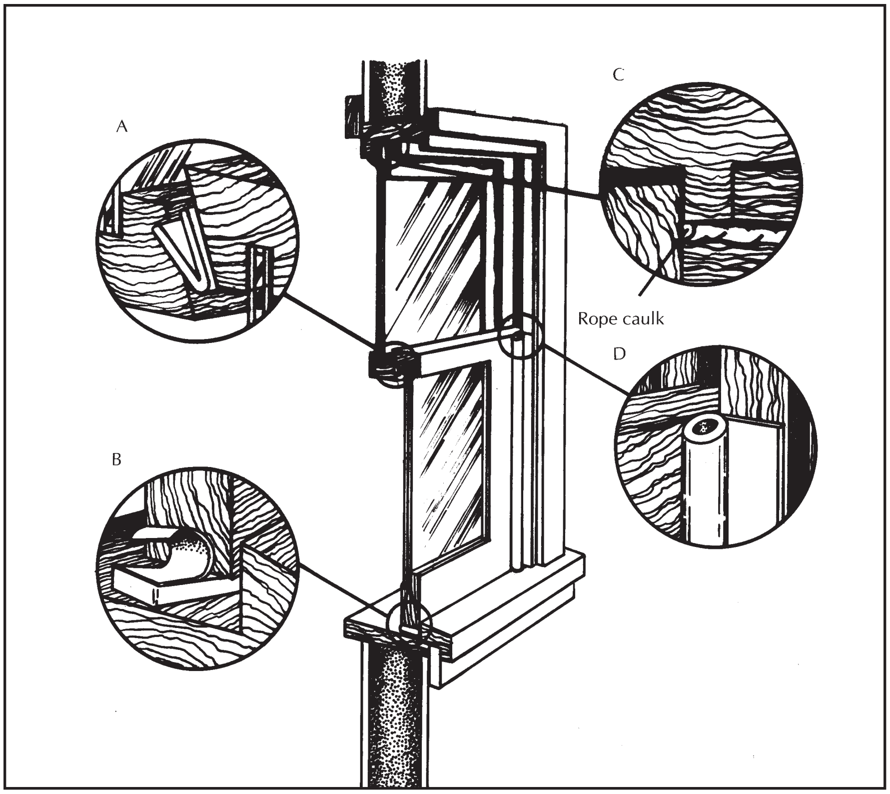


Figure 3
Different types of weatherstrip material are available for specific parts of a window. (A) Use V-strip at the "meeting rail" of a double-hung window; (B) Use self-stick adhesive backed foam at the bottom of the sash; (C) Removable rope caulk makes a good weatherstrip at the top sash; (D) Attach tubular weatherstrip to the side frame to help stop air leakage through the sash.

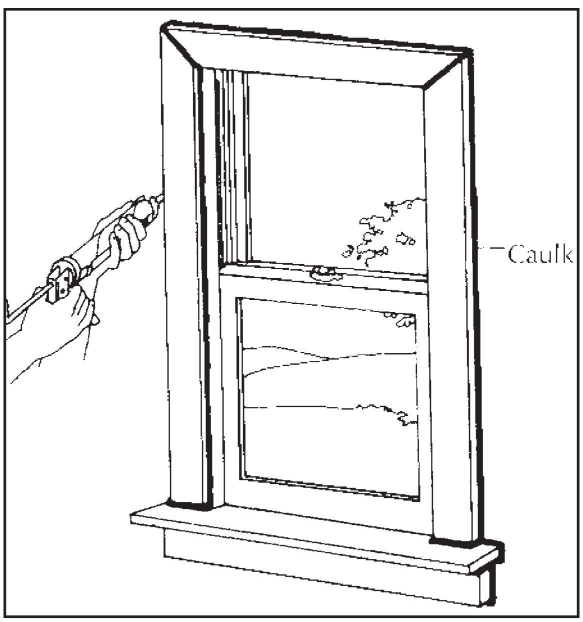


Figure 4
Apply caulk to stop air leaks at seams around the window frame.

You can purchase windows with a built-in shading effect (similar to sunglasses for your house) that selectively blocks the ultraviolet and infrared rays, while allowing the visible light to pass through. The level of "tint" or degree of shading is referred to as "shading coefficient" and should not be confused with low emissive coatings, which block all wave lengths of light equally. The lower the shading coefficient, the greater the shading effect. A coefficient of 0.5 to 0.3 is the recommended range of shading for residential windows, placing the low factor (0.3) windows on the east and west sides to keep out the summer sun, and the high factor (0.5) windows on the north and south side. Ordering the right shading coefficient for each window may be expensive, but if you are committed to energy saving, this option may be worth considering.

Energy efficient doors: what to look for

Today's market offers a wide range of handsome doors that are significantly more energy efficient than old style doors. As with windows, it is the insulating quality (expressed in U-value), air tightness, and installation that are the principal factors affecting energy efficiency. Look for the following features when shopping for doors.

Insulation-filled steel doors provide much higher R-values than doors without an insulated core. The most common door of this type has a steel face and is filled with polyurethane insulating foam. To understand its efficiency, consider that a typical wood panel door has a U-value of about 0.5, while an insulated steel door can have a value as low as 0.17.

Insulated fiberglass doors offer the advantages of insulated steel doors and have an appearance similar to wood. They are paintable and stainable and do not readily expand or contract in response to temperature and moisture changes. Some of these doors have U-values as low as 0.17.

Glass patio doors have developed a bad reputation as energy wasters based on the old style aluminum frame, double-panel sliding door. A number of improvements have been made, however, to significantly increase their energy efficiency. These include low-emissive coated, double glazed doors with gas filling. Another attractive energy efficient option is the terrace or atrium style door with one fixed panel and the other panel on hinges. (See Figure 2.) Air infiltration is much reduced with this type of door compared to a sliding door. Many are available with a U-value of less than 0.37.

Weatherstripping is extremely important in preventing air infiltration around doors. Magnetic weatherstripping is commonly used on steel doors to provide a tight seal. The threshold or door bottom, a critical spot, should be made of material that is flexible enough to conform to different clearances and to tolerate extreme temperature changes and wear. Since door weatherstripping is vulnerable to damage, it should also be easy to replace, so ask your sales representative to demonstrate how to remove and apply weatherstripping. (For more information, call the Energy Information Center.)

Proper installation is as important for doors as it is for windows. Follow the same recommendations listed under window installation to ensure that the door fits snugly into the rough opening. Seal any existing gaps between the door frame and the wall with caulk.

Storm doors can be an attractive addition to your home while they provide additional insulation value, reduce air infiltration and protect your prime door from the weather. Storm doors are not absolutely necessary if your prime door is steel or fiberglass and has an insulating core. However, if your prime door is made of wood, a storm door is essential. Some storm doors come equipped with screens to allow for summer-time ventilation.

Combustion Air Caution

Whenever you caulk around windows or take other steps to reduce air leakage, it is important to make sure your furnace, water heater, and other fuel-burning appliances have sufficient combustion air. If they don't, backdrafting of carbon monoxide and other gases into the home could occur.

For information on combustion air, how to test for problems, and how to install a combustion air supply, call the Energy Information Center and ask for a copy of the Combustion Air guide.

HOME
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Home Heating

Minnesota Department of Commerce Energy Information Center

A comfortable and healthy home environment requires and efficient and sound heating system. Such a system heats the home without using large amounts of energy, and it does not endanger the indoor air quality by overtaxing the supply of oxygen needed for combustion.

It is important periodically to evaluate your heating system. It is especially important not to wait until a crisis occurs. A cold night in January, with the furnace faltering or failed, is not the time to assess your heating system. Do it now.

This guide is-designed to help you assess your present heating system and determine if it is satisfactory, if improvements are needed , or whether the system should be replaced. If you determine a new furnace is needed, this guide will help you decide what type of unit to install. This guide also describes how to maintain your furnace- and how to modify your current furnace to improve efficiency. The term "furnace," as used in this guide, generally refers to both furnaces (which distribute heated air) and boilers (which distribute heated air) and boilers (which distribute heated water). Recommendations or descriptions that apply specifically to boilers are noted.

Advances in technology have brought major improvements in heating systems over the past decade, including furnaces that use much less energy during a heating season and furnaces that bring in air from outside and supply it directly to the combustion process.

In assessing your present system, compare it with new, improved systems. An old furnace, even when it's running well, may extract only 60 percent of the available heat from the fuel over the heating system. That means only 60 cents of your heating dollars is going into the house as heat; the rest is going up and out the chimney. In contrast, the best of the new furnaces are so efficient that they waste less than a nickel of very dollar spent.

You should also consider the amount of electricity used by a forced-air furnace, which can add significantly to the monthly costs of your heating system. Some new high efficiency gas furnaces have features such as a variable speed motor that reduce electric use.

You will also want to consider your present heating system in the context of the entire home. If, for example, you have added insulation, tightened up air leaks, or taken other measures to improve energy efficiency, it is critically important to ensure that fuel-burning appliances such as furnaces and water heaters have and adequate supply of combustion air. The section on safety (page 11) can help you determine whether your present heating system poses a health threat.

Repair vs replacement

Your first step is to decide if your present furnace operates properly. If your furnace is old, or has a serious malfunction that will cost several hundred dollars to fix, it may be wise to replace it. As a general rule of thumb, if your furnace is more than ten years old and costs more than $500 to fix, it should probably be replaced in place of repair.

If your furnace is old but not broken, deciding when to replace it can be difficult. Average life expectancy of furnaces in homes today is between

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Basement Insulation

16 and 20 years. If your furnace is close to this age or older, being shopping. This holds true for boilers as well, although boilers have grater life expectancy, 30 years. Be prepared to replace your furnace or boiler. Shopping for a replacement furnace in an emergency does not allow time to get fair market pricing.

The design of your house and the size of your utility bills may be deciding factors. Generally, if you have a large house with high heating bills, it could be more cost-effective to purchase a high efficiency furnace now rather than wait for your present furnace to wear out.

If you decide to repair your furnace, look for a heating professional who has experience with your type of heating system.

Buying a new furnace

Whenever you purchase a new heating system the primary factors to consider are: the type of fuel you are going to use, how the heat will be distributed throughout the house, what size furnace to buy, and the efficiency rating.

Type of fuel. If you have a choice of fuels, you will want to consider which is the most affordable in the long run. See the table Comparing Fuel Costs

Heat distribution. Consider the opportunities offered by different distribution systems. The primary difference between 'furnaces' and 'boilers' is that a furnace uses air to distribute heat throughout the house and a boiler uses water. Forced air systems allow easy installation of traditional central air conditioning, since the same ductwork can be used to distribute warm or cool air. This makes a forced air systems more economical if you plant to install central air conditioning.

Furnace size. Furnace size is almost as important as the efficiency rating. The most common mistake is buying a heating system too large for your home. Remember, the notion that 'bigger is better' does not apply to heating or air conditioning systems. If your heating system is oversized, it can create temperature swings in your home and reduce comfort.

Unfortunately, there are no simple rules for furnace sizing. The Energy Information Center recommends that you ask a heating professional to do a heat loss calculation to ensure that you are buying the right size. Many municipalities require a heat loss calculation at the time the contractor requests a permit to install your heating system. A heat loss calculation includes factors such as the window area, type of windows, insulating properties of the wall, and the amount of heat loss through air leakage. Discuss any remodeling plans with your contractor. Ask any contractor who bases estimates solely on the square footage of your house to do a true heat loss calculation. If you are considering buying a central air conditioner at the same time as a new furnace, be sure that the air conditioner is sized properly. If your cooling unit is sized too large, it will not do a good job of dehumidifying.

Furnace efficiency. The Energy Information Center recommends that you look for a furnace with an AFUE (annual fuel-utilization efficiency) of more than 90 percent and a sealed combustion system (see figure 1). In addition, consider buying a furnace with a variable speed blower motor to improve electrical efficiency. Our recommendation for boilers is an AFUE of 84 percent or greater, with a sealed combustion system or a mechanical exhaust. If a high efficiency heating system is out of your price range, consider those furnaces and boilers with mechanical venting (see description of mechanical venting further on in this booklet). The more efficient a unit, the more heat (Btus) you will receive from your fuel.. See the Sidebar on Understanding Efficiency Ratings. Remember, however, that an efficient heating system is only one component contributing to your home's efficiency.

Choosing a heating contractor. A new heating system costs money – anywhere from $2,000 to more than $4,500. When buying a new heating system, you should compare prices. It isn't unusual for bids to differ by as much as several hundred dollars. You should receive written bids on the cost of equipment and installation from at least three contractors, and ask each for the names of customers who have had their heating system for a few years. When evaluating bids, look at prices but also pay attention to and compare quality, energy savings, and warranties. If you are putting in a high efficiency furnace or boiler, ask if the contractor has special training in this type of installation. If you think your old

Look For:

Kitchen Exhaust Fans

Clothing Dryers

Whole house vacuums.

All exhaust air from you home

Anything that exhausts air from your home affect the operation of furnaces water heaters and fire places.

If and when you make a change you need to be assured the other appliances will be working properly.

heating system is covered with asbestos insulation, discuss this with the contractor. Make sure they follow the proper procedures in dealing with asbestos removal.

A new heating system must be installed properly. Furnaces and boilers should be tuned and a combustion efficiency test performed after installation.

Make sure the contractor is fully bonded and insured. Heating contractors are licensed by your city, not the state. Your local licensing office may be a good resource for information on contractors in your area. Another source for a listing of contractors is the Sheet Metal Air Conditioning and Roofing Contractors Association (SMARCA), phone 612-593-0941. Look for a company that does installation and repairs. For more information on selecting a contractor, ask for a copy of "Hassle-Free Home Building and Remodeling" from the Minnesota Attorney General's Office, 651-296-3353, or 800-657-3787. Also available at www.ag.state.mn.us.

New high efficiency furnaces

A high efficiency furnace with sealed combustion or mechanical venting saves you money over the life of the furnace, reduces the chances of backdrafting furnace gases into the home, and contributes to a healthier environment.

The economic benefits can be surprising. For example, if you change from a furnace with 60 percent efficiency to a furnace with a 90 percent or higher efficiency, it is possible to save 30 to 40 percent on your annual fuel costs. Depending on whether you heat with gas, oil or propane, savings could be $250 to $500 per year. From a safety standpoint, efficient furnaces and water heaters with mechanical venting or, better yet, a sealed combustion system, greatly reduce the danger of backdrafting.

Some of the features to look for in a new furnace are described below and illustrated in Figure 1.

Mechanical vent. Forced draft or induced draft refers to the use of a fan or blower to push or pull the exhaust gases out of the chimney rather than relying on natural draft. The term "mechanical draft" is also used to describe this feature. Forced draft is necessary I today's furnaces. As more heat is extracted from combustion gases,

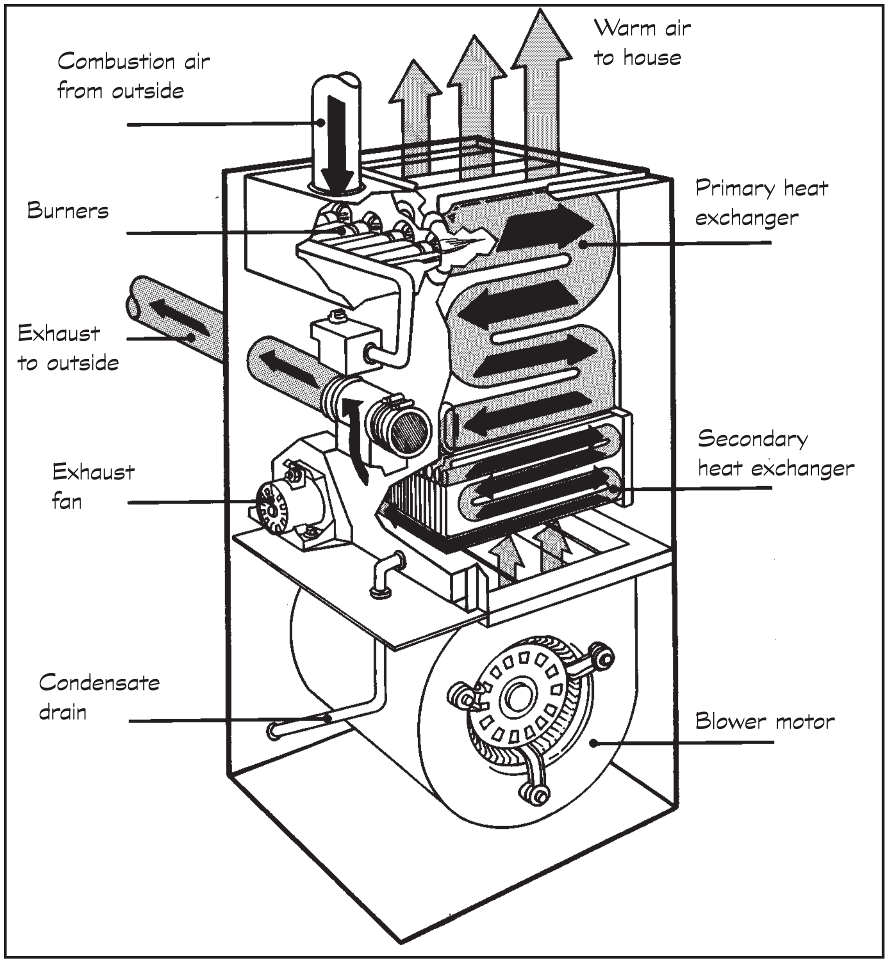


Figure 1
This typical high efficiency furnace has a second heat exchanger that extracts more heat from the combustion gasses before exhausting them to the outside. It also has a sealed combustion chamber that allows for a consistent, reliable source of outside air for combustion and a means of venting the combustion gases directly out the side of the house.

Ensure Safety!

Ensuring the safety of a home heating system is essential. Buying a furnace with a sealed combustion system and equipping your home with a carbon monoxide detector are two ways to protect yourself from carbon monoxide poisoning. See page sidebar Safety is Number One Concern for more information.

they are cooled and become less likely to rise naturally up the chimney. The exhaust of indoor air by other appliances compounds the problem. Bath and kitchen exhaust fans, cook top exhaust systems, clothes dryers, and loss of indoor air through attic bypasses all contribute to the danger of an inadequate supply of indoor air. Forced draft is an important feature to look for in any furnace, water heater, or boiler. Some forced draft furnaces provide for venting combustion gases out the wall rather than up the chimney. If you purchase that type of furnace and you have a combustion water heater, the water heater exhaust vent may need to be readjusted (see "one important caution" under Sealed combustion below).

Sealed combustion is especially recommended. This feature dramatically increases safety and efficiency since there is no mixing of the air in the furnace with the air in your house. You will not be using your warm room air for combustion. Because the exhaust is usually vented directly out the sidewall through a plastic pipe, you do not need a traditional chimney connection. This allows more flexibility in where you place your furnace. Sealed combustion also keeps indoor air pollutants from entering the furnace, causing corrosion or other damage to the furnace. *One important caution: if you replace your furnace with a furnace that is vented out the side of the house, it is especially important to have your heating contractor assess and readjust, if necessary, the flue or vent on the water heater to help safeguard against backdrafting.* Recent studies indicate that fuel-burning water heaters are a significant source of backdrafting in Minnesota homes.

Electric and other types of heating systems

The efficiency of electric heating equipment is measured in terms of Coefficient of Performance (COP). A COP of 1.0 means that the heat energy the appliance delivers is the same as the electrical energy it uses: it operates at 100 percent efficiency. Heat pumps that extract heat from the ground or earth can actually operated at greater than 100 percent efficiency and many have a COP of higher than 3.0.

Despite their high efficiency, electric units – at current prices of electricity – may cost more to operate than oil, natural gas, or propane furnaces. Energy- and cost-saving options are available, however, that may make electric heating cost competitive. For example, many utilities offer a discount rate to customers willing to have a portion of their power cut off during periods of high demand, usually somewhere between 8 a.m. and 8 p.m. daily. To qualify for these rates usually requires having a back-up fuel source or a thermal storage system. Call your utility to see if discount rates are available.

A back-up fuel source such as fuel oil or propane can be used when electricity is interrupted. The main considerations are availability and cost of the back-up fuel as well as how the heat would be distributed throughout the house. Under this agreement, the customer's power may be interrupted any time the utility experiences a high demand for power.

Another way to qualify for discount rates is with a thermal energy storage system. This system requires a large thermal mass to absorb heat and store it for release during the utility's daily peak demand period, when power from the utility is shut off.

Various types of electric systems are listed below.

Baseboard resistance heaters are the least expensive to install, but they are the most expensive to operate. They usually do not allow taking advantage of special low electric rates, since they lack the capacity to store heat.

Electric furnaces, in addition to supplying heat, also allow for air conditioning to be added, and some models can accommodate thermal storage devices. Since electric furnaces can lose a significant amount of heat through the seams in ductwork, make sure these points are well sealed.

Radiant heating. Electric heating cables, in the past mainly installed in ceiling or wall panels, are now more often installed to provide radiant heat in floors. In-floor radiant heating also can be provided by water, heated by a boiler or ground source heat pump. The heated water circulates through plastic tubing fastened beneath a wood floor, in a cement floor, or in a lightweight cement overlay on an existing floor. In-floor radiant heating provides more constant heat then baseboard heaters, allows for a lower thermostat setting, but also takes a longer time to adjust to changes in temperature. Radiant heating is most easily installed during new construction or major remodeling and is appropriate for energy-saving zoned heating.

Electric thermal storage systems (ETS) operate with resistive electric heat during the utility's off-peak hours, allowing homeowners to substantially reduce their heating costs by taking advantage of off-peak discount rates. ETS furnaces use either ceramic bricks or water to store heat and are available as a central furnace or room heater. If you are building a home, you can bury heating cables in sand or earth beneath concrete slab floors; however, if you choose this method you must insulate under the cables (R-10) is the recommended level) or you will lose a large amount of heat to the ground. ETS systems can prevent energy waste by varying the amount of heat stored according to the outdoor temperature.

Heat pumps. Unlike furnaces, heat pumps do not burn fuel to produce heat. Instead, they transfer heat from one place to another, much like your refrigerator does. To accomplish home heating, a pump extracts heat from the ground, air, or water and distributes warm air to your house, usually through a forced air system. Heat pumps can be reversed to provide air conditioning in the summer. The heating performance of air source heat pumps is rated by the HSPF (heating season performance factor), ground source heat pumps by he COP (coefficient of performance). HSPF is determined by the estimated seasonal heating output divided by the seasonal heating output divided by the seasonal power consumption for the average U.S. climate. The Energy Information Center recommends that HSPF of 8.5 or higher for air source heat pumps and a COP of 3.2 or higher for a ground source closed loop heat pump.

Although a variety of heat pumps are available, a horizontal closed loop ground source heat pump appears to be the most practical for Minnesota because deep earth temperature remains at a fairly constant 50° F. year round. Heat pumps are more expensive to buy and install as a retrofit.

Keep in mind that whenever your heat pump or air conditioner is serviced, the refrigerant should always be recovered and properly recycled and never vented into the air.

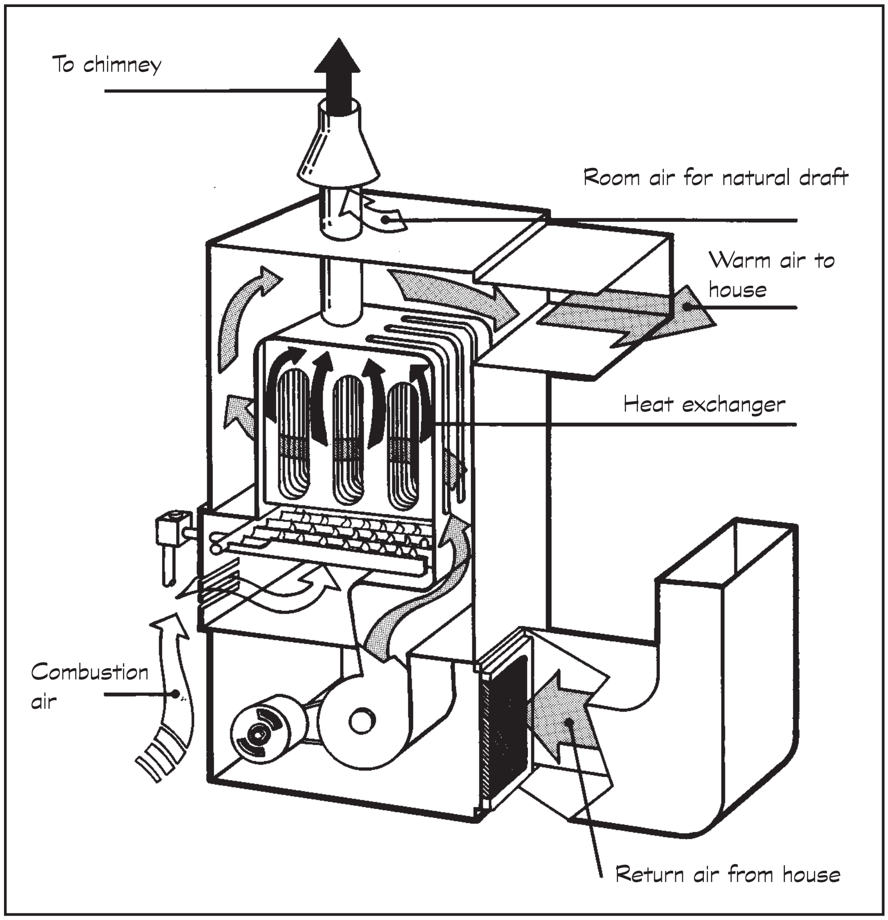


Figure 2
This traditional, low efficiency furnace uses room air for combustion, has a single heat exchanger, and relies on natural buoyancy to exhaust the host combustion gases through the chimney.

Understanding Efficiency Ratings

AFUE (annual fuel utilization efficiency) applies to gas and oil furnaces and measures efficiency over the entire heating season, telling you how much of your fuel dollar is converted into heat. Similar to a miles-per-gallon rating for your car, the higher the AFUE the more efficient the furnace. An old, poorly maintained gas forced-air furnace may have an AFUE of only 50 to 60 percent, while the most efficient of the new designs have ratings of higher than 90 percent. The AFUE does NOT include Electrical Energy Consumption.

According to federal law, all gas or oil burning furnaces manufactured after January 1, 1992, require a minimum of AFUE of 78.2 percent.

Steady-state applies to gas and oil furnaces and measures how well your heating system operates while it is running. Use this rating to compare the combustion and heat exchanges efficiency of different models.

COP (co-efficient of performance) measures the efficiency of electric heating equipment. A COP of 1.0 indicates 100 percent efficiency, meaning that the heat energy you receive from the furnace is exactly equal to the energy if consumes. Heat pump equipment usually has a COP of greater than 1.0 because it acquires heat energy from an external source and uses electrical energy to move that heat indoors in winter - outdoors in summer.

SEER (seasonal energy efficiency ratio) measures efficiency of central air conditioning or heat pumps in the cooling mode. Like AFUE, SEER measures how efficiently the equipment operates over the season. The most efficient models have SEERs of 13 to 14.

HSPF (heating season performance factor) measures the heating efficiency of air source heat pumps. It is the ratio of heating energy produced to energy consumed: it is determined by dividing the seasonal heating output in BTU's by the seasonal power consumption in watts.

Recent advances in technology have produced some totally new types of heating systems. These include:

Combined space heating/water heating systems combine water and space heating into a single unit. Although the cost of space heating remains about the same as with a high efficiency furnace, the cost of water heating is significantly reduced – up to 40 percent. If your household uses a lot of hot water (if you have teenage children, for example), this type of system could bring considerable savings.

Variable rate furnaces use considerably less electricity – as much as 60 percent less – than other forced-air furnaces. Features include microprocessor controls, which automatically adjust air flow to achieve maximum efficiency. In addition to savings energy, these furnaces are quieter in operation and increase comfort by eliminating the rush of cold air (cold shot) when the furnace cycles on.

Maintaining your furnace and duct system

Keeping your heating system well maintained and properly adjusted is important for every system – new or old. A qualified service person should periodically check, clean, and tune your furnace, not only for energy efficiency but also for safety. Make sure the duct, is sealed. Sealing duct work with aluminized duct tape can improve the efficiency of your cooling system and reduce heat loss. It may be a good idea to ask a heating specialist to balance the heating system.

All oil and gas furnaces should be tuned every year, unless the manufacturer directs otherwise.

Do-it-yourself maintenance measures include:

- Change the furnace filter once a month.
- Clean the blower at least once a year.
- Make sure registers and radiators are not blocked by furniture or draperies.
- Bleed radiators, baseboard heaters, and other systems that use heat radiation once a year.

Operating your furnace

How you operate your heating system affects how much energy you use. Follow these suggestions to lower your heating bill:

- Turn down thermostats in unused rooms, at night, and when you are going to be gone for more than four hours during the day. Automatic setback thermostats can do this for you (see below).
- Have your heating contractor adjust the fan thermostat for an efficient on-off temperature.
- Close off both the supply and return registers to the basement or other unused rooms.

Modifying your furnace

If you decide not to replace your furnace, you might think about modifying it to improve efficiency.

Warning: Furnaces are designed with safety in mind. Changing the way a furnace operates may upset its operation, which can have dangerous repercussions.

If your furnace is more than 10 years old, the better investment is to put the money proposed for improvement toward a new high efficiency furnace. Because boilers have a longer life expectancy (30 years), the cut off for improvements would be between 15 and 20 years.

Interest in improving efficiency has spawned dozens of devices to modify existing furnaces. Beware of add-on devices that claim to save energy. Some of these produces might work, but others will actually raise your fuel bill, damage your heating system, or pose a danger to your family.

Whether or not a device is good or bad depends on the characteristics of your furnace. It is therefore important to consult a qualified heating contractor or service person before using any of these products.

The equipment and alterations that are known to be safe and effective in some situations are:

Automatic setback thermostat. Lowering the thermostat at night or during the day while you are away will save one percent for every one-degree-Fahrenheit per eight hours of setback. Manually resetting the temperature twice a day will not cost anything, but this can be inconvenient. Instead, you can get an automatic setback thermostat to do the work for you. Some are relatively inexpensive and pay for themselves in a very short time.

How a Furnace Works

The basic operating process is the same for all furnaces and boilers regardless of the type of fuel they use.

- The thermostat calls for heat and starts the ignition and combustion process. Fuel is delivered to the combustion chamber, mixed with air, and ignited to produce heat in the form of hot gases.
- These hot combustion gases flow through the heat exchanger, warming it. The combustion gases exit the furnace and are exhausted from the home.
- A control with the heat exchanger starts the fan.
- This process continues until the room thermostat anticipates enough heat is left in the furnace to bring the house up to the temperature set by the thermostat. The thermostat then tells the burner to shut off. The furnace fan continues to run until the heat exchanger thermostat turns the fan off.

Older furnaces and boilers depend upon natural buoyancy of the hot air or hot water to distribute heat within the home. This same natural buoyancy is depended upon to exhaust gases from furnaces and boilers. Changes in efficiency of equipment and in the characteristics of homes require that furnaces manufactured today use fans to push the exhaust out of the home.

Comparing Fuel Costs

In deciding which heating fuel to use, a comparison of costs helps.

To compare costs, you must first convert the fuels into a common unit - BTUs, which is a measure of heat energy. Below is a list of fuels and the amount of each required o produce 1 million BTUs:

Natural Gas	10 therms or 10 mcf	=	1 million BTUs
Electricity	293 kilowatt-hours	=	1 million BTUs
Propane	10.9 gallons	=	1 million BTUs
Heating Oil	7.21 gallons	=	1 million BTUs

The average Minnesota home uses 80 to 100 million BTUs annually for heating. Using statewide averages for fuel costs, the table below lists the cost per million BTUs of the various fuels and calculates the annual cost of producing 100 million BTUs of heat. It is important to note that only an electric heating system operates at 100 percent efficiency. To determine the annual cost of providing 100 million BTUs of usable heat from all the other fuels, the efficiency factor of the heating system must be considered. For example, a natural gas furnace with an AFUE of 90 delivers 90 percent of the BTUs into the home as heat. To provide 100 million BTUs of usable heat, therefore, the furnace must produce 111.1 million BTUs for an annual cost of $555. On the other hand, a ground source heat pump with a COP of 3.2 uses only 31.2 million BTUs of purchased electric energy to produce 100 million BTUs of usable heat; the annual heating cost would be $640.

Fuel	Cost per unit	Cost per million BTU	Annual fuel costs*
Natural gas	$0.50 per therm	$5	$500
[furnace with AFUE of 90	$0.50 per therm	$5	$555]
Electricity	$0.07 per kWh	$20.51	$3,051]
[ground source heat pump	$0.07 per kWh	$8.72	$640]
Propane	$0.80 per gallon	$6.50	$650
Heating oil	$0.90 per gallon	$6.50	$650

*for 100 million BTUs of delivered heat

Vent dampers. This device automatically blocks off the vent pipe after the burner shuts off. This prevents warm air from escaping up the vent when the furnace isn't running. On the average, you will save about six percent on your fuel bills with a vent damper.

Dampers are either thermally or electrically operated. Thermal dampers, the cheapest but least effective of the two, open and close by the change in exhaust gas temperature. Electric dampers are much more effective, since they are timed to go on and off with the burner. They also have a built-safety feature that prevents the burner from lighting if the damper fails to open.

All vent dampers must pass certain safety standards before installation is permitted by the State Building Code. If they are not up to standard, or are improperly installed, they can be extremely dangerous. If the damper doesn't open when the burner comes on, combustion gases will build up in the house.

Chimney liners. An oversized chimney wastes heat and drafts poorly. One solution is to put in a correctly sized metallic line to reduce air flow. A liner also extends the life of masonry chimneys by preventing deterioration from the flue gases. Liners must be properly installed and tested by a qualified service person to make sure combustion gases do not spill into the living space. This is especially important if you are replacing your furnace but not the combustion water heater; in some cases the chimney liner may have to be replaced to reduce the risk of backdrafting (see the caution under the description of sealed combustion furnaces earlier). If you have a gas furnace with a masonry chimney, you must have a metallic liner. Have your contractor inspect for this.

Oil burner replacement. In most cases, replacing the old burner with a new high efficiency burner is the most economical modification that can be made to an oil furnace. In fact, you can expect a new burner to increase the efficiency of your present furnace by about 15 percent. Have your heating contractor assess the possibility of making this improvement.

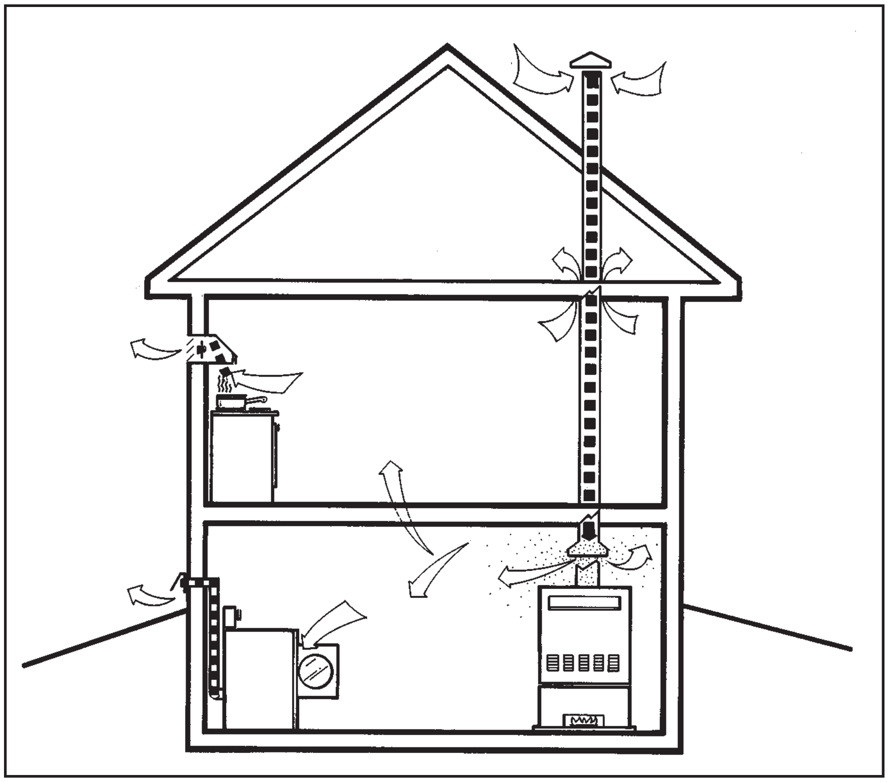


Figure 3
Arrows show pattern of home air movement. Exhaust fans for stove, clothes dryer, and other appliances reduce the amount of fresh air in the home and can result in furnace exhaust gases backdrafting.

Safety Is a Number One Concern

When a fuel such as gas or oil is burned, the main combustion products are water vapor, carbon dioxide, and nitrogen oxides. If these gases are not vented properly to the outside, serious problems can develop – problems that affect your personal health, your furnace, and your home.

The most publicized – and most serious – of these problems is carbon monoxide poisoning, which causes illness or death among Minnesotans every winter. If these is too little oxygen to burn the fuel, combustion is incomplete, producing carbon monoxide, a colorless, odorless gas that can quickly build up to dangerous levels. Other dangerous gases, including nitrogen oxides, formaldehyde, and other aldehydes, can also build up and cause serious health problems, especially when combined with poor ventilation.

An indicator of a serious problem is the buildup of moisture in the house. Backdrafting of combustion appliances such as a water heater or furnace, and a leaky cracked heat exchanger, will increase moisture in the house. One hundred cubic feet of natural or natural gas produces more than a gallon of water in the form of vapor. If not vented, this vapor condenses on any cool surface (and incidentally, can cause serious damage to the house structure.)

Because this moisture normally exhausts out of the chimney, excessive humidity in your house may be a warning sign that your gas furnace or other fuel-burning appliance is not venting properly. Other indicators of gas furnace problems are frequent headaches, a burning feeling in nose and eyes, nausea, disorientation and other flu-like symptoms, and a yellow rather than blue combustion flame. With an oil furnace, warning signs are black chimney smoke, a fuel smell in the house, soot accumulation, and a popping or banging sound caused by late ignition or insufficient combustion air.

If you suspect a problem, air out your house, open a window near the furnace room, and immediately call your heating contractor, utility, or service technician.

For help in preventing combustion air problems, call the Energy Information Center. We recommend buying a furnace has a sealed combustion system or, at a minimum, a furnace that forces the exhaust gases our of the home with a fan. We also recommend that you install a carbon monoxide detector in your home.

Combustion air test. You can perform a simple test yourself to see if your furnace is venting properly. There are more details available in our Combustion Air Guide.

- Close all windows, exterior doors, and bedroom doors.
- Open all interior doors.
- Turn on all exhaust fans, the clothes dryer, and waterheater.
- Turn on the furnace and wait a minute for the draft to stabilize.
- Hold a smoking object (incense stick or match) about two inches from the draft hood opening. If the smoke is drawn into the hood, the furnace is venting properly. If the smoke is blown away from the hood, combustion gases are spilling out and you must correct the problem. Open a window a crack in the furnace room and call a heating contractor at once.

Be wise: weatherize

Weather or not you buy a new furnace, it is a good idea to weatherize your home. Adding insulation and strategically caulking and weatherstripping will make your home more comfortable, save energy, and reduce the size of the furnace you need if you are going to purchase a new system. As your heating load decreases, the size and cost of a heating system required to meet that load also decreases. You might consider having a home energy efficiency analysis performed. Sometimes referred to as an energy audit," this is a detailed examination of your home's energy use often provided at no or low cost by utilities. Check with your utility to see if it provides an audit.

It is important to remember that if you tighten your home you must make sure that you have adequate indoor ventilation.

Bibliography

American Council for an Energy-Efficient Economy (ACEEE) 6th edition, T*he Most Energy Efficient Appliances 1995,* available from bookstores for $8.95 or from 1001 Connecticut Avenue N.W. Suite 801, Washington, D.C. 20036, 202-429-0063 or www.aceee. org

Energy Information Center publications are available free. They include Combustion Air, Home Energy Guide; *Drafthood Test for Combustion Air,* a check for homeowners; and *Furnace and Boiler Tune-Up,* a check-list for homeowners.

HOME ENERGY GUIDE

TECHNIQUES TACTICS & TIPS

Water Heaters

Minnesota Department of Commerce Energy Information Center

Water heating is often the second largest energy expense in the Minnesota home, and may account for up to 20 percent of annual household energy costs.

Buying a new water heater

Sizing and installing a water heater system

Avoiding waste in using hot water

Related Guides:
Low Cost/No Cost Ideas
New Homes
Combustion Air
Indoor Ventilation

There are three ways of reducing hot water expenses: improve the efficiency of your present hot-water heater or purchase a new high efficiency model. You also can use less hot water.

Buy new, or keep the old?

Water heaters have an average life expectancy of 10-12 years, but they can last much longer. Most are not replaced until the tank fails and it begins leaking. In many cases, however, it is wise to change the heater long before the water begins accumulating on the floor.

An old water heater can operate for years at very low efficiencies before it finally fails. It is often cheaper to remove an operating, but inefficient, older unit and replace it with a new highly efficient model.

There are also instances when a properly operating model should be replaced. For example, if you have an energy efficient furnace that exhausts through the side of your house, and your chimney is in need of repair or a liner, you may want to consider replacing the existing water heater with one that would exhaust through the basement wall, not needing the use of a chimney. Fixing the chimney while continuing to pay more for hot water may cost considerably more than simply capping the chimney and buying a new water heater that also vents out through the side of the house.

If your water heater tank is leaking, then your course is clear: buy a new unit. But if it isn't, your answer is less obvious.

Ask yourself some questions:

- Does the water heater make popping or cracking noises?
- Have you been forced to turn the temperature setting up over time to maintain an adequate supply of hot water?
- Do you have very hard water?
- Look under the burner. Is there a buildup of rust or other deposits?
- Open the drain tap at the bottom of the heater. Is the stream of water equal to any faucet? If the stream is small or nonexistent, then you have a big buildup of scale inside the heater that is wasting energy.

CAUTION: If your heater is old and does have a scale buildup, you may not be able to close the drain tap. Be prepared to shut off the water with the valve at the top of the tank and use a wrench to tighten the drain tap.

If you answered "yes" to several of these questions, a new hot-water heater is probably a good investment.

If your answers indicate that the heater is operating well, call the Energy Information Center and ask for the Home Energy Guide, "Low cost/no cost energy ideas." It contains several good tips on improving the operation of hot water heaters.

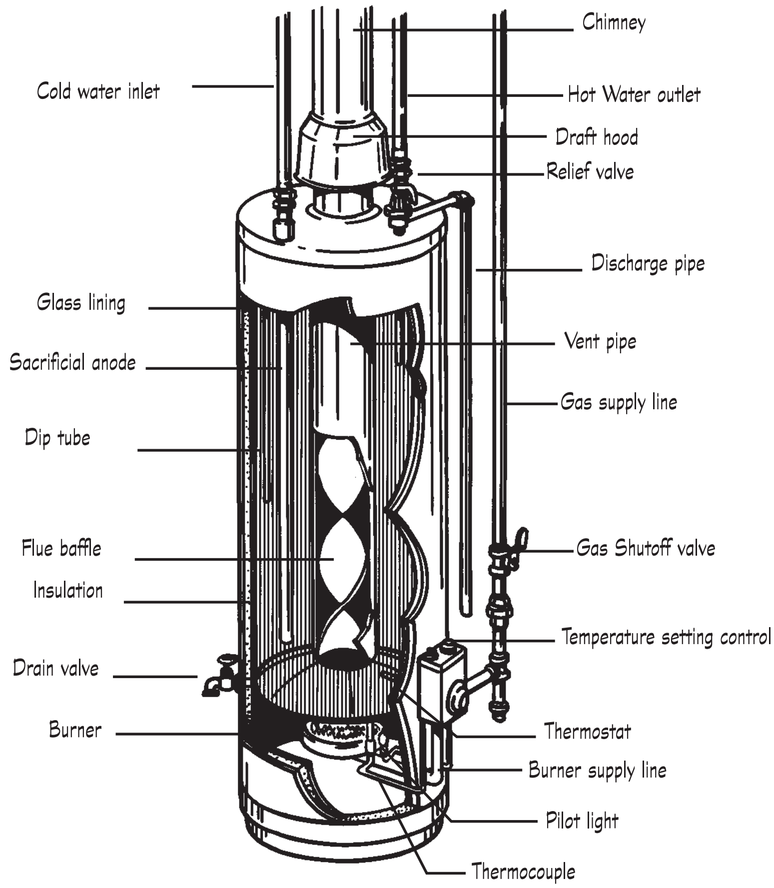


Figure 1
Gas water heater

Switching fuels

Before switching to a different fuel, make sure it will really save you money. Find out how much it will cost for piping and wiring. Make sure there is proper space for the water heater. Check to see if additional plumbing will be needed.

If you use electricity, call your utility and ask about the availability of off-peak rates, and how they can save you money.

If you must replace an old heater, then you may save money by using a different fuel – but not always. If gas is already in the house for clothes drying or space heating, replacing a malfunctioning electric hot-water heater with a natural gas unit may be a good decision.

If you have any questions regarding fuel switching, call the Energy Information Center.

Buying a new hot-water heater

When you do decide to install a new water heater, buy an energy efficient model. It will cost a little more, but the extra cost will pay for itself in a few years time. After that, the better efficiency will save you money for the life of the water heater.

A conventional water heater is a fairly simple appliance. It consists of a storage tank and a source of heat. The tank is usually steel and coated with glass or enamel to prevent corrosion. It is covered with insulation and enclosed in a steel jacket.

The most common sources of heat are a gas burner or an electric resistance heating element. Both are controlled by a thermostat that keeps the water temperature constant.

Gas hot-water heaters. The most common size natural gas water heater is 40 gallons. Typical gas models have a burner under the tank and an exhaust stack/heat exchanger which runs through the middle of the tank (Figure 1).

The exhaust stack has two functions: it is a vent for the burner and it transfers heat to the water. A gas heater is usually taller and thinner than an electric model.

Variations of this standard design are available. An example is the **submerged combustion** or **wet base** water heater. The burner sits inside a combustion chamber completely surrounded by water. The tank is insulated on the bottom to reduce heat loss to the floor.

Many newer gas water heaters do not vent the exhaust up a chimney. They may use a small electric fan motor that pushes the exhaust out through the side of the house. A few side venting water heaters still rely on natural draft to remove exhaust gases.

Don't rely on design features alone to assure energy efficiency. Read and use the rating found on the yellow and black Energy Guide tag found on all new water heaters. The tag will tell you the estimated yearly cost of operating the unit. Call the Energy Information Center for help in identifying the most efficient water heater.

Electric water heaters. Electric models use resistance coils inside the tank (Figure 2). Electric water heaters typically have slower recovery rates and larger tank size than water heaters that rely on combustion. Some models have only one heating element, others have two. Quick recovery electric heaters are available.

Although electric water heaters are generally more expensive to operative than natural gas models, they do have some advantages over gas. Electric units have no flue pipe, so you can put one almost anywhere in your home: in a closet, under a sink, etc. The entire tank is surrounded with insulation so less heat is lost when compared to a standard gas model.

Space heat-water heater combinations. Almost all high efficiency boilers will heat water. This may be done with an indirect fired water heater, also known as a “sidearm” water heater (Figure 3). This is a separate zone of heat flow from the boiler to an insulated tank. The hot water flows through a water-to-water heat exchanger which in turn heats the water in the tank. Some boilers may also have a coil inserted into the boiler itself, but this is not as good an idea: it’s less efficient than the sidearm. When considering such a unit, make sure that the boiler is not too large for your home heating needs, and that the water heater is reasonably priced.

Point-of-use water heaters. Point-of-use water heaters are also called “tankless” heaters because they have no storage tank. They are relatively small units that provide hot water on demand. They use gas or electricity for fuel, and can be installed near demand points, such as under kitchen sinks. They are often more expensive than a conventional water heater. Gas units may also require a large, expensive flue and will increase space heat loss up the chimney. The large energy input may overload many existing chimneys, preventing them from exhausting properly. Electric units need updated wiring.

Another major drawback is capacity. A tankless heater typically provides 1-2 gallons of hot water a minute. You may find this adequate. However, you may not have enough hot water for more than one use at a time. Before installing a tankless water heater in your home, make sure its reduced capacity will be adequate for your needs.

Heat pump water heaters. Heat pump water heaters (HPWH) extract heat from air and put it into the hot water tank. They can be more efficient than electric hot-water heaters, but can also be more expensive.

Heat pump technology has been around as long as refrigerators and air conditioners, but only in recent years has the concept been applied to heating water. The flow of heat is opposite that in a refrigerator or air conditioner. Instead of taking heat out of a container and dispersing it into the air, the HPWH takes heat from the surrounding air and pumps it into a tank filled with water.

There are two types of heat pump water heaters: integral and remote. The integral unit is a heat pump with its own water tank. The remote unit is a heat pump that can be connected to an existing electric resistance heater. The remote unit is cheaper than an integral heat pump and can be easily added to an existing system.

Both types have a resistance element as a backup, either built into the integral unit or left over in the old system to which the remote unit was added. Heat pump water heaters use about half as much electricity as resistance heaters to do the same job.

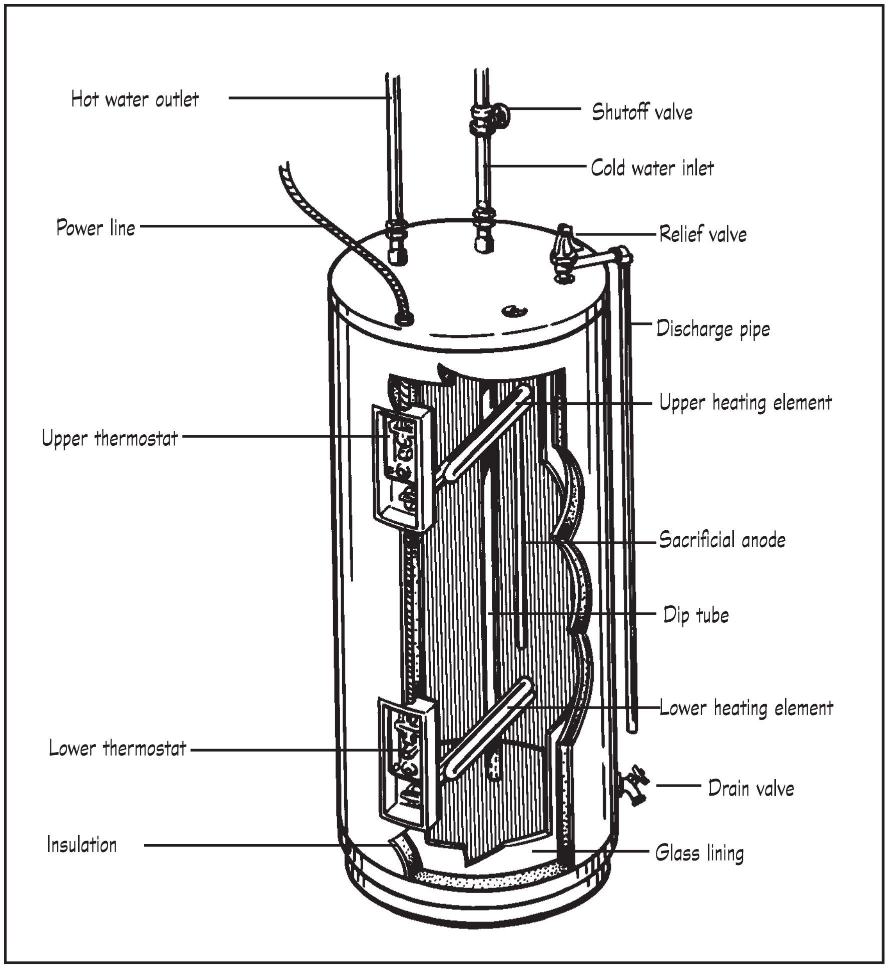


Figure 2
Electric water heater

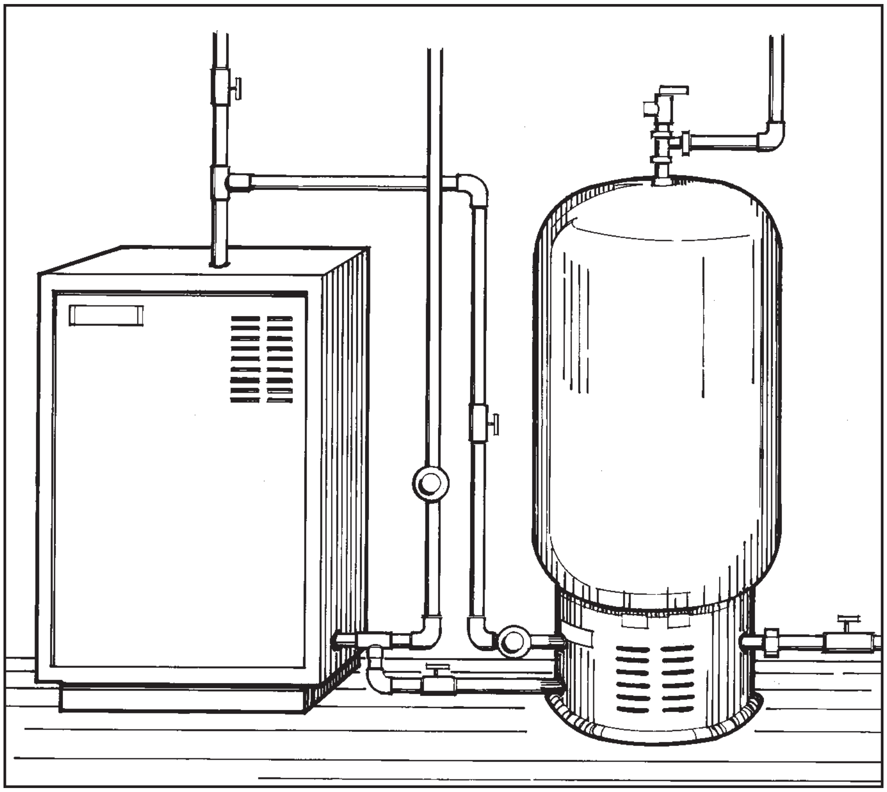


Figure 3
Space heat-water heater combination (also know as a "sidearm" water heater).

A HPWH also lowers the temperature of the air around the heat pump. In summer the cooling and dehumidification provided by the HPWH amounts to free air conditioning. During the heating season, the HPWH unit will rob heat produced by the space heating system.

Whether or not this is a disadvantage depends on the cost of the fuel used and annual efficiency of your space heating system.

One disadvantage of the HPWH is its low recovery rate: 10 to 15 gallons per hour, somewhat less than the recovery rate of a typical electric water heater. To avoid hot water shortages, the size of the hot water tank should be increased.

Solar water heaters. Solar water heaters can reduce the annual fuel cost of supplying hot water to your home by more than half. Throughout the year, the solar system preheats the water before it reaches the conventional water heater. During the summer, the solar system may provide all the required heat. Many homeowners report the the most noticeable result of installing a solar water heating system, in addition to lower water heating bills, is that they no longer run out of water with heavy hot water use.

A solar water heater typically includes collectors mounted on the roof or in a clear area of the yard, a separate storage tank near the conventional heater in the home, connecting piping, and a controller. The cost of a solar water heater in Minnesota may be justified if the traditional energy costs are high (such as heating water with high cost electricity) and the installation is fairly straight forward.

National organizations currently certify the quality and performance of solar collectors. Look for the Solar Rating and Certification Corporation (SRCC) label and compare performance by using the SRCC rating numbers. Use only quality equipment and experienced installers. Obtain competitive bids from at least three firms.

Energy efficient water heaters

Until recently, all gas water heaters sent their exhaust out of the house through a standard chimney. These natural draft heaters consume large quantities of indoor air. In some cases, the draft in the flue can be reversed and spill dangerous fumes into the house. This does not happen with a sealed combustion or a side-vent system.

Sealed combustion. This type of water heater brings air directly into a combustion chamber without mixing with house air. A sealed combustion heater does not need a chimney, since its exhaust gases are blown from the side of the house with a fan (Figure 4). This eliminates the potential danger of the hot-water heater backdrafting into the house.

Side-vent heaters. Because these heaters blow the exhaust out through the side of the house, the traditional flue or chimney is not needed for the heater. Some side vent heaters are sealed combustion types, while others use house air for combustion. All side-vent heaters allow for greater installation flexibility; the water heater can be put closer to where the water is used instead of next to a chimney.

Kits to modify an older heater to exhaust through the side wall are available, but they can be expensive to buy and install. In some cases, the cost can be as much or more than an entirely new heater. As with any product added to an appliance, it should have an American Gas Association, Underwriters Laboratory or other appropriate listing agency approval for the appropriate water heater. It should not void the warranty of the appliance.

Remember: any modification work done on your vent system must be inspected and approved by local building officials.

Water-space heating combinations. Some high efficiency furnaces and most high efficiency boilers can provide hot water throughout the year. For health and safety reasons, only a unit specifically designed to do this should be used.

Some manufacturers have developed integrated appliances: one appliance that will heat the house, provide air conditioning and heat water as well.

Heating water with wood. Wood is sometimes used to heat water and there are a few products on the market for this purpose. Anyone who is considering this should be cautioned that it is difficult to do safely. A tempering tank in the same room, but which is *not* connected to the wood stove is one safe way. Some wood-fueled boilers can provide domestic hot water needs.

It is recommended that you buy a wood boiler or water heater that has been tested and listed for heating water by Underwriters Laboratories or equivalent agencies.

Sizing, installing a water heating system

It is important to buy the right size hot-water heater: Too small and you may run out of hot water in the middle of a shower; too large and you'll pay for hot water that is never used.

To find the size you need, determine the time of the day when your household uses the most hot water. Use the chart to list how and how many times the hot water is used in one hour during the peak period. Multiply the number of uses by the average amount of hot water consumed by each activity and add the totals to find your peak demand.

Normally, you should buy a water heater than can handle your peak needs.

But if you reach that peak only once a week, and use less hot water the rest of the time, try adjusting your life-style to spread out demand, and buy a smaller heater.

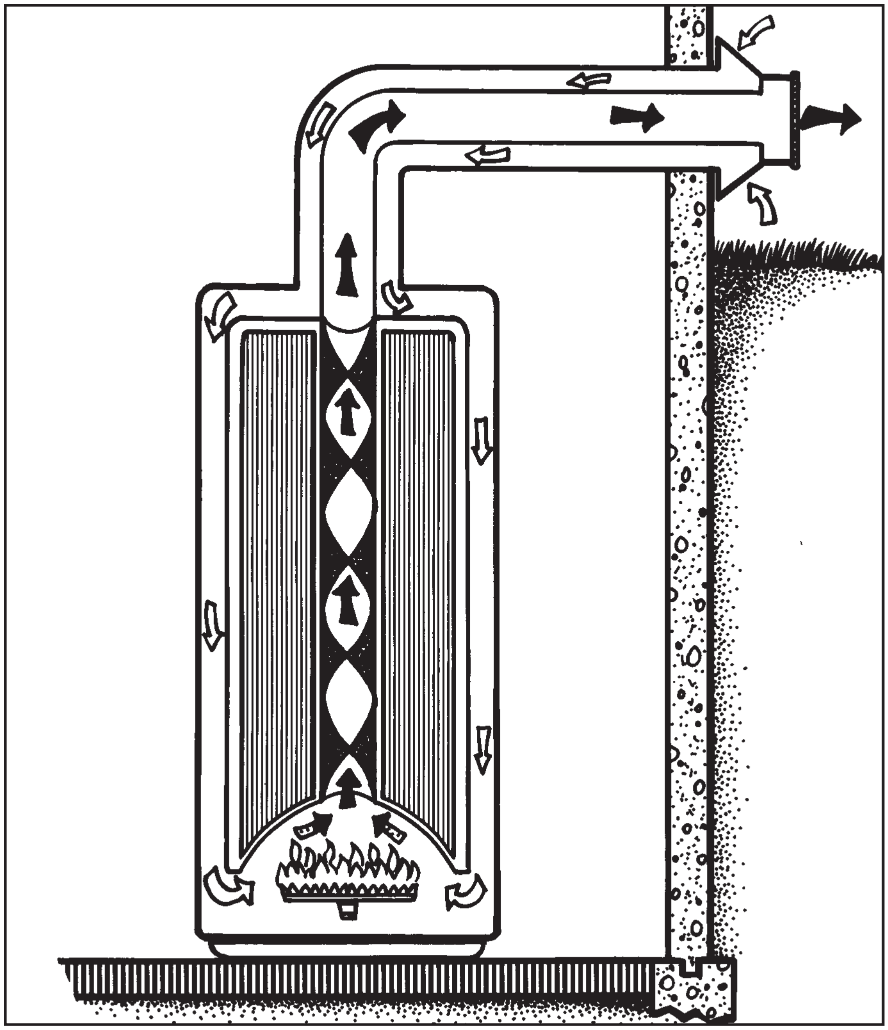


Figure 4
Sealed-combustion, side-vent water heater.

When installing your new hot-water heater, place it as near as possible to where the largest amount of hot water is used. Use pipe insulation and heat traps to conserve energy.

Pipe insulation. Water pipes extending vertically from the hot water storage tank are really part of the tank itself. The lighter hot water flows up the pipe, replacing cooler and heavier water. Insulate both pipes with foam or fiberglass from the tank to the heat trap, or to the first horizontal run (Figure 5). Insulation should be kept at least three inches from the draft hood and flue.

Heat traps. Heat traps may be natural or mechanical, and may reduce the amount of heat lost when water isn't being used by 12 percent. Some new heaters have them installed at the factory. The natural trap is a piece of tubing bent in the form of a "U." (Figure 6.) Mechanical traps are available with a ball type check valve.

	GALLONS OF HOT WATER	X TIMES USED	=	GALLONS
	USED PER ACTIVITY	IN ONE HOUR		PER HOUR
Shower	20	________	=	________
Bath	20	________	=	________
Shaving	2	________	=	________
Hand, face wash	4	________	=	________
Shampoo	4	________	=	________
Hand dish washing		________	=	________
Auto dish washing	14	________	=	________
Food preparation	5	________	=	________
Auto clothes washer	32	________	=	________
PEAK HOURLY DEMAND			=	________

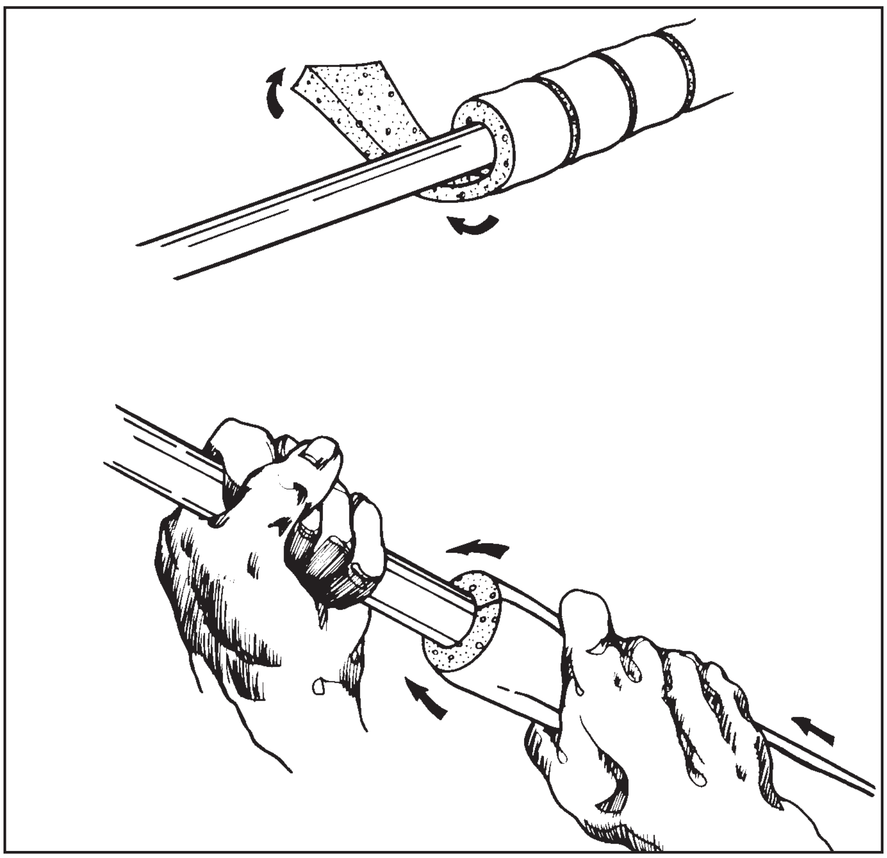


Figure 5
Pipe insulation

Water heaters without heat traps and with vertical pipes should have the traps installed on both the inlet and outlet pipes.

The heat trap should be as close to the tank as possible.

Tempering tanks. A tempering tank pre-heats water by absorbing heat from household air and is worth considering if an inexpensive source of space heat is available, such as a wood stove. These may also be used seasonally by using warm outdoor air to preheat the incoming water. Tempering tanks may be made from an old water heater with insulation removed, or a simple water storage tank.

Make sure the tank is clean and free of any toxic materials.

Using less hot water

Avoiding waste in using hot water is an effective way to reduce energy costs.

Fix leaky faucets. A hot water faucet leaking one drop a second will waste about 60 gallons of hot water a week. This could cost you up to $35 or more a year. Leaks can usually be fixed by replacing the tap washer. Turn off the water below the sink or tub (or at the main supply if you don't have a shut-off valve below the fixture), take the faucet apart, replace the bad washers, and put the faucet back together.

Install flow restrictors on faucets. Flow restrictors on faucets will save money on both the water bill and water heating costs. They reduce the amount of water you use for tasks that require flowing water without greatly changing the feel of the flow. Restrictors cost anywhere from less than a dollar to about $3. To install, simply unscrew the aerator at the end of the faucet and push the restrictor in. If you don't have aerators on your faucets, consider installing them. If you can do it yourself, it will be worth it in water and energy savings.

Install a water-saving showerhead. A typical showerhead uses between four and nine gallons of water a minute. A water-saving showerhead uses between two and three gallons per minute, which means it can save you one to seven gallons per minute; and most of the water is hot. If your water heater is set at 120°, and if your family takes two five-minutes showers a day, you can lower your yearly gas bill by over $20 or you're your electric bill by about $40 (based on you saving two gallons of water per minute in your shower). If you save more than two gallons per minute, your savings will increase.

Other easy hot water savings tips. Wash only full loads of laundry, or adjust the water level for smaller loads. Use cold water whenever possible.

Run the dishwasher with full loads only. Don't use the hot rinse.

Use cold water to flush away food in your garbage disposal.

Turn off your water heater, or place it on its lowest setting, if you are going to be gone for a few days or more.

Don't let the hot water run when you are shaving, washing dishes by hand, or doing similar tasks.

If you have an electric water heater, check into "time-of-day rates." Some electric utilities offer very cheap electricity during times when there is little demand for it. If you can switch 60 percent or more of your electric use to this "off-peak" time (usually between 9 p.m. and 9 a.m.) you can probably save some money.

Summary

When looking at a new water heater, be sure to compare the energy efficiency of different models by checking the Energy Guide label. Higher initial cost for these features will save you money in the long run. Energy efficient units are better insulated, while high efficiency natural gas units now use less gas.

Buy the smallest size you can. Don't try to buy a water heater so you can shower, and wash clothes and dishes all at the same time without running out. Instead, plan your hot water use. This is especially important if you have a large family.

Locate the water heater as close as possible to where the largest volume of hot water is used. Since heat is constantly lost through hot water pipes, the shorter the pipe runs, the lower the heat loss.

Insulate the water pipes and install heat traps.

Take easy, low-cost or no-cost measures to avoid waste in using hot water.

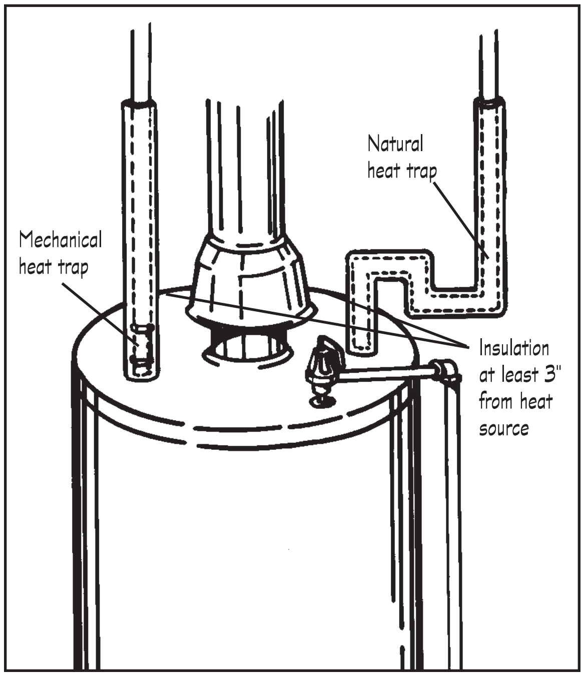


Figure 6
Pipe insulation and heat traps.

Don't set water temperature too high

Very hot water can cause scalding burns and be a severe hazard, especially to small children or the elderly. To reduce the danger of scalding, turn the temperature setting down to 110° or 120°. In most cases, that will be low on the scale.

The water heater may not have a temperature control setting marked in degrees; Measure the temperature at the tap with a thermometer.

Preventing Combustion Air Problems

Recent research has identified serious combustion safety problems related to leaky ducts serving forced air heating systems. Air from the basement leaking into return ducts depressurizes basement areas, causing heaters to back-draft and exposing residents to toxic combustion products, including carbon monoxide. This problem is potentially worse in the summer due to a variety of conditions. Homeowners and contractors should consider thorough sealing of return air ducts in basements. In addition, it is essential that water heaters as well as furnaces and boilers have a source of air for proper combustion and exhaust.

For information on testing for and installing a combustion air supply in your home, call the Energy Information Center and ask for a copy of the guide on Combustion Air. The Energy Information Center also recommends that you purchase an electronic carbon monoxide detector. Make sure it is listed by the Underwriters Laboratory and has a digital display and a memory feature.

HOME ENERGY GUIDE

TECHNIQUES TACTICS & TIPS

Combustion Air

Minnesota Department of Commerce Energy Information Center

The fuel-burning appliances in your home need a reliable supply of outside air to work properly. Your furnace, water heater, and other flame producing devices such as fireplaces and wood stoves use large amounts of air in the combustion process. To ensure safe and efficient operation, that air must constantly be replaced while the appliances are operating.

This replacement air is commonly called "combustion air" and its importance cannot be overemphasized. Without enough combustion air, your house can quickly become polluted with unhealthy gases, including deadly carbon monoxide (CO). Carbon monoxide is odorless, colorless, and highly poisonous.

No special means of supplying combustion air is provided in most older homes – the needed air was simply assumed to flow in through leaks in the structure. We realize now, however, that the air in our homes is dynamic. 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 air leakage to provide sufficient combustion air.

The Minnesota building code requires that all new homes be built with a special duct that brings outside air directly to the heating system. This requirement makes it less likely that there will be a shortage of combustion air, but it does not guarantee it. Other fuel-burning appliances such as wood stoves, fireplaces, and water heaters need combustion air, and bath and kitchen exhaust fans affect the availability of combustion air.

What causes dangerous combustion air problems?

Most furnaces, 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, or through the combustion air duct (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 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. *(see also Wood Heat)*

Wood fires are not the only cause of backdrafting. Although combustion air problems are more like-

Related Guides:
- Wood Heat
- Indoor Ventilation
- Home Heating
- Home Cooling
- House Diagnostics

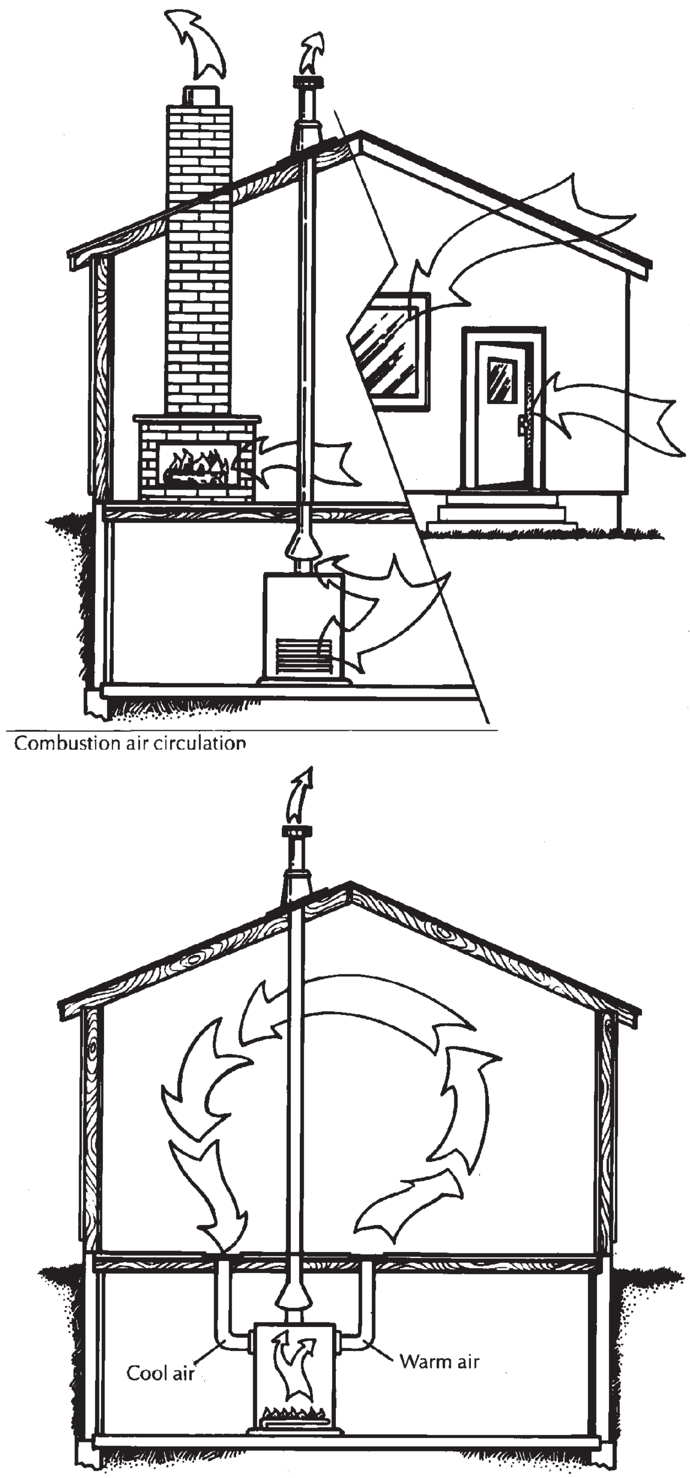


Figure 1.

ly to occur when there is an open wood fire, they are not limited to situations in which there is a wood fire. 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.

As noted above, 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 number of home improvement or weatherization measures may increase the potential for backdrafting: for example, making our homes more comfortable and energy efficient by tightening up air leaks, adding insulation, or replacing windows. So, too, does the recent consumer trend of installing professional cooking appliances with built-in high-volume exhaust fans. These fan/exhaust systems are powerful and often remove more air from the home than what can be supplied through leaks or passive openings. It is extremely important to remember that any time we take these or other measures that affect air pressure in the home, care must be taken to provide replacement air.

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

You can easily check for combustion air by performing a 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.

You must perform the draft hood test at least twice. If you have a fireplace or wood-burning stove, you need to do it a third time. The tests should be performed on a mild day with very little or no wind. It is important to remember that the draft hood test is a “snapshot” of air performance in your home at one particular moment. A change in wind speed or direction, or an open window, might change the result. It is recommended that you perform the test at least a couple of times over the heating season.

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. If the smoke is drawn in, your flue is clear. If it is blown away from the hood, it is essential that you check the flue for obstructions before operating the furnace. Call a heating professional.

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. Make sure all storm doors and storm windows are 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 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 a window in the furnace room or open other basement windows or doors to the outside and leave them open until you can provide a permanent combustion air supply.

Test 3. If you have a fireplace or wood stove, 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 to use the fireplace or wood stove only with a nearby window or door open until you can provide fresh air from a permanent duct.

Even if the fireplace or wood stove passes the test, a separate combustion air supply is still needed for each wood-burning appliance.

Other warning signs. In addition to conducting the draft hood test, certain warning signs should definitely 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. Following are other warning signs:

Carbon Monoxide Detector

The Energy Information Center strongly recommends installing a carbon monoxide (CO) detector in the home. The detector sounds an alarm after CO reaches a dangerous level. Make sure the detector has a UL listing. You should consider buying a detector with a low level digital display and a memory, in addition to a simple alarm. These features help diagnose a problem if one is discovered. CO detectors need to be tested regularly and cleaned as indicated in the manufacturer's instructions. If the unit operates off a battery, the detector should be tested weekly and the battery replaced at least once a year. For more information on CO and its health effects, call the Minnesota Department of Health at 612-215-0909.

Figure 2

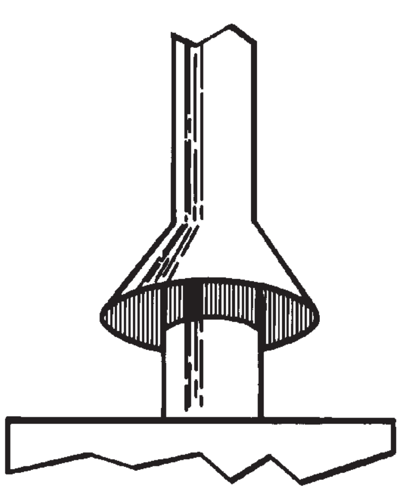


Figure 3

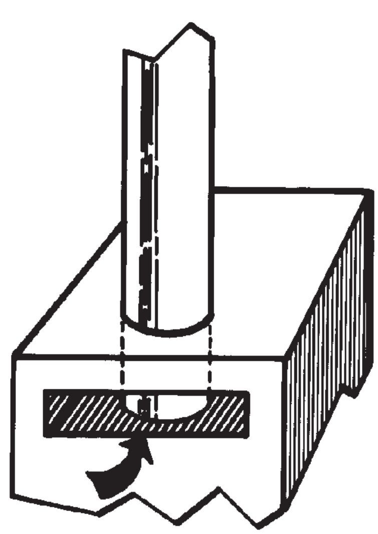
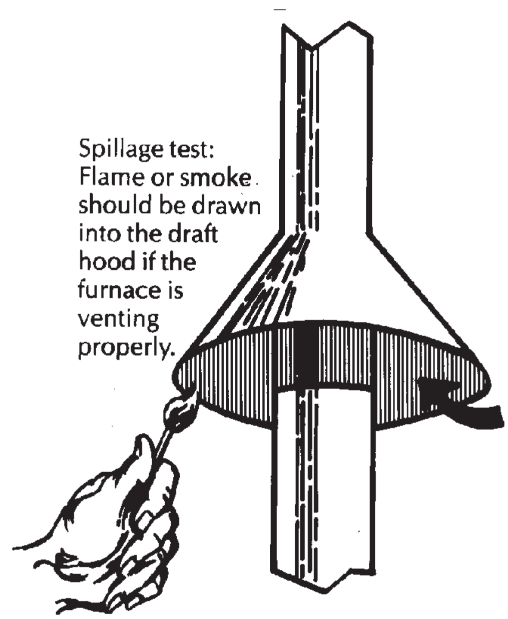


Figure 4



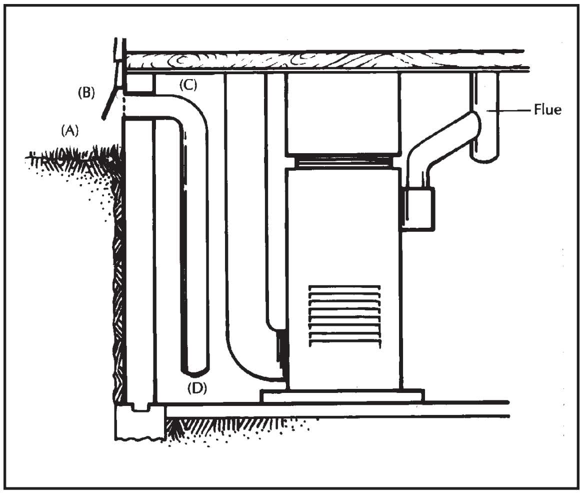


Figure 5

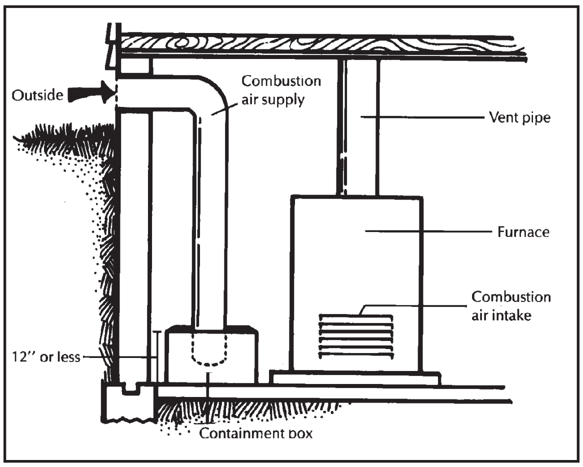


Figure 6

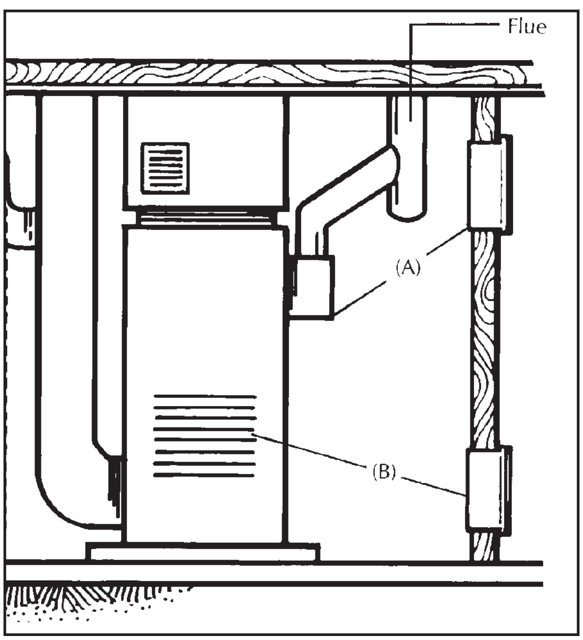


Figure 7.

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.

If you suspect a problem with combustion air, 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.

Outside combustion air supplies for the furnace

Whether or not you identify a problem, it is always wise to provide an outside combustion air supply.

Sealed combustion. Some new furnace, boiler, and water heater models use sealed combustion: that is, the combustion air is brought directly into a combustion chamber. 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 recommend you buy a sealed combustion or power-vented unit. A word of caution, however: even if you buy a sealed combustion furnace, you must still supply outside combustion air for the other fuel-burning appliances in your home.

Installing your own combustion air supply. If you do not have a sealed combustion furnace, you can provide an outside combustion air supply yourself. Be sure to have your local building inspector check your work.

Two methods of installing an outside combustion air supply meet Minnesota building code requirements. The Energy Information Center recommends, however, that you use only one method, which is described below. The second method, which brings outside air into the return air duct, has two major drawbacks: it results in warm, humid air being brought into the home during the summer, increasing the load on the air conditioner and possibly causing summer moisture problems. In the winter, this same method may bring in excessive amounts of cold air, increasing air pressure within the home. This could result in moist indoor air being driven into walls and ceiling, potentially causing severe moisture problems in the house structure, including window and door frames.

The recommended method of supplying combustion air brings a duct from the outside to the vicinity of the furnace's combustion air inlet, which draws up the combustion air (Figure 5). When using this method, the state building code requires that the outside air intake (B) be one foot or higher than the outside ground level (A), that the intake be protected by a screen of 1/4-inch mesh, that the duct is at least the diameter of the flue (C), and that the supply outlet is not more than one foot above the floor (D).

To reduce cold air around the furnace, build a closed-bottom containment box out of sheet metal and drop the combustion air supply duct into it (Figure 6). The box or pail cannot be more than one foot high. Attach the pipe permanently to the container.

If the floor area of the furnace compartment is less than two times that of the floor area of the equipment, the building code requires that ventilation air be supplied to the confined space through two openings (Figure 7). The first opening must be placed above the drafthood opening and must be 1-square-inch for each 2000 Btus-per-hour capacity of the furnace (A). For example, an 80,000 Btu/hour furnace would require a ventilation air grille of 40 square inches. There must also be an opening of the same size (B) at a point below the combustion air inlet on the furnace.

Outside combustion air for fireplaces and wood stoves

Because fireplaces and wood stoves require large amounts of combustion air, it is an especially good idea to provide them with direct supplies of fresh air. It will make your house much safer. *(see also Wood Heat)*

With a fireplace, air from the outside should be brought through a duct that connects to an air vent directly in front of the fireplace grate. (Figure 8). The diameter of the duct will depend on the air needs of the fireplace.

The vent should be the same size as the duct so that it can be well sealed to prevent cold air leakage. The air vent should be easy to open and close so that when the fireplace is not in use it can be closed to prevent drafts.

You can install the duct through a basement window, the rim joist, or the basement wall as long as these locations are at least 12 inches above grade. If you bring the duct through the wall, seal around the hole. If the duct is placed through a window, cut a piece of board to fit in the window and around the duct, then weather-strip and caulk it, and insulate around it. (The window cannot be one that is used as an emergency exit.) You must install a 1/4-inch screen over the opening to keep out animals and debris.

Energy Savings

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. Energy losses occur when more cold air, which has to be heated, is brought into the house to meet combustion air requirements. Combustion air and makeup air supplies are health and safety concerns and must be addressed. Buying an energy efficient, sealed combustion furnace and water heater provide energy savings as well as increased safety.

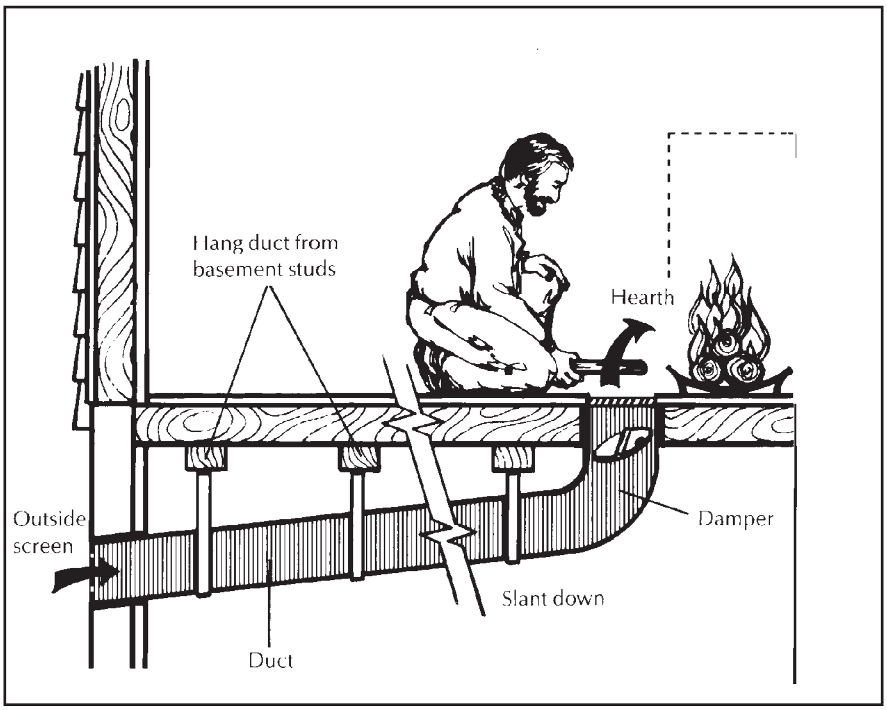


Figure 8.

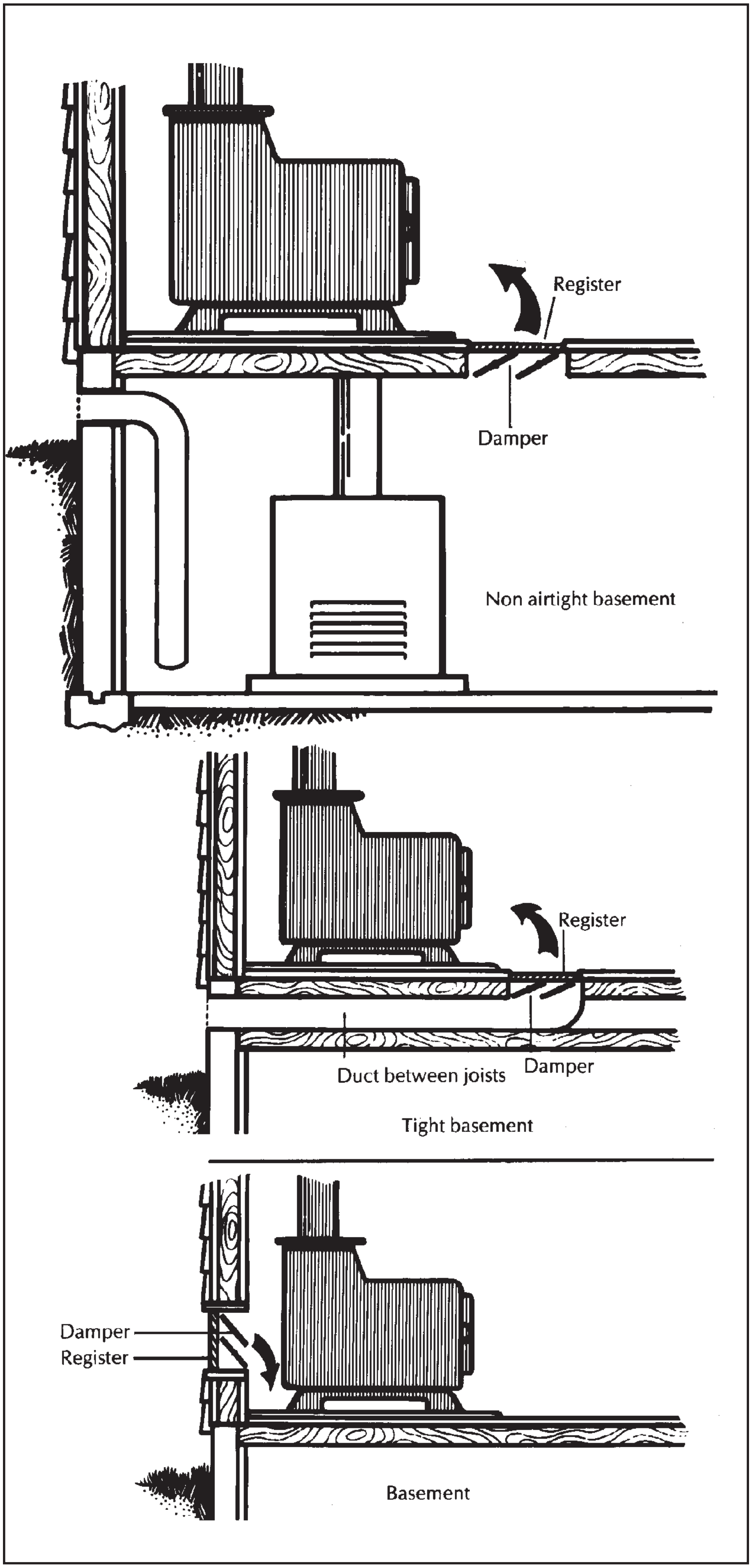


Figure 9.

A makeup air hood on the outside is strongly recommended.

The duct can be hung from the basement joists and should be tilted slightly downward toward the outside to prevent condensation from running down into the basement.

A tight-fitting damper – which is allowed in a wood system – is a good idea. You can use the damper to control the amount of draft when the fireplace is in use, and to help prevent cold air from leaking in when it's not in use.

Once the duct is in, take care to seal all the joints with high temperature metal tape and insulate it with noncombustible material. If it is possible, the air vent should be installed so that a glass door can be put on the fireplace. The vent should be between the glass door and the grate and will ensure that only outside air will be used for combustion.

Installing an outside combustion air supply to a wood stove is basically the same as for a fireplace (Figure 9). The simplest method is through an opening either under or in front of the stove that provides an air passage through the basement or crawl space. Air can also be brought directly from an outside wall of the house to the stove. Always install a tight damper to help control the draft and to prevent air from leaking in when the stove is not in use.

Combustion air should not be brought directly into the wood stove unless the stove is designed for it, and then only with a proper installation kit.

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 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 has sealed combustion), or adding an exhaust fan. Consider installing an additional source of air to make up for any air exhausted elsewhere.

Important Points to Remember

- 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: they produce 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.
- Never use a gas range or oven for heating a room.
- If you have a new house that has an outside combustion air opening to your furnace, never block it.
- 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 require a separate chimney. Never vent them into the existing heating system chimney.
- Never use unvented equipment indoors. This includes propane, gas and catalytic heaters, and gas lanterns.
- Unvented kerosene heaters should never be used indoors. Unvented kerosene space heaters are dangerous. The Energy Information Center does not recommend the use of any unvented heaters in any enclosed space. Exposure to emissions constitutes a health risk, even under relatively high ventilation conditions.
- Additions and remodeling change the air leakage characteristics of your home. Always test for combustion air during and after any remodeling project.

HOME ENERGY GUIDE

TECHNIQUES TACTICS & TIPS

Home Cooling

Minnesota Department of Commerce Energy Information Center

Keeping cool in summer is becoming nearly as important as keeping warm in winter. Air conditioner sales continue to rise as more and more people consider an air conditioned home to be essential. Our desire for personal comfort, however, carries a price tag. As electric utilities strain to meet summer demand, they are sometimes forced to purchase expensive power from other sources or to build new power plants. The result is higher electric bills for customers and harmful environmental impacts from increased power plant emissions.

Learning to cool efficiently will lower monthly energy bills and also help the environment. This guide presents a wide range of energy saving strategies, including passive cooling methods, effective use of fans, guidelines for purchasing air conditioners, and tips on efficient operation and maintenance of air conditioning equipment.

Passive cooling — a good place to start

Understanding how your house is affected by different types of heat gain will help you take steps to reduce heat without using mechanical cooling.

Heat is absorbed from the sun's rays, which in summer are almost directly overhead (see Figure 1). Heat also comes from warm, moist outdoor air entering the house through tiny cracks around windows and doors, numerous other small openings, and the foundation and other porous materials. Finally, heat is generated inside the home by people, appliances, lighting, cooking, and bathing.

Reducing solar heat gain. Strategic planting of deciduous trees significantly reduces heat gain from the sun's rays. Give first priority to planting shade trees due west of west-facing windows; planting shade trees east of east-facing windows is second priority. Also, installing awnings, sunscreens, or overhangs can reduce heat gain by as much as 90 percent while still letting in light. Keeping shades and curtains closed on the sunny side of the house also reduces heat gain. *(see Landscaping)*

Reducing infiltration. A good way to understand cooling is to think about how your house works in winter. The same measures that keep the cold out and the heat in during a January cold snap do the reverse in an August heat wave. Weatherizing measures to reduce air flow in and out of the house are fundamental conservation measures in any season. These include insulating, caulking, and weatherstripping. Keeping windows closed during the day (and opening at night to take advantage of cool breezes) also reduces heat gain, as well as leaving storm windows or plastic coverings on windows that do not need to be opened (the extra insulation helps keep the heat outside). *(see Home Insulation)*

Reducing indoor heat generation. Some easy cooling steps that cost little or nothing and bring immediate results are to:

- Schedule heat-producing tasks like baking and vacuuming during the cooler evening or morning hours.
- Use covered electric frypans, microwave ovens, or similar small appliances, rather than the oven, for cooking.

Related Guides:
Home Heating
Landscaping
Home Insulation
Combustion Air
Basement Insulation

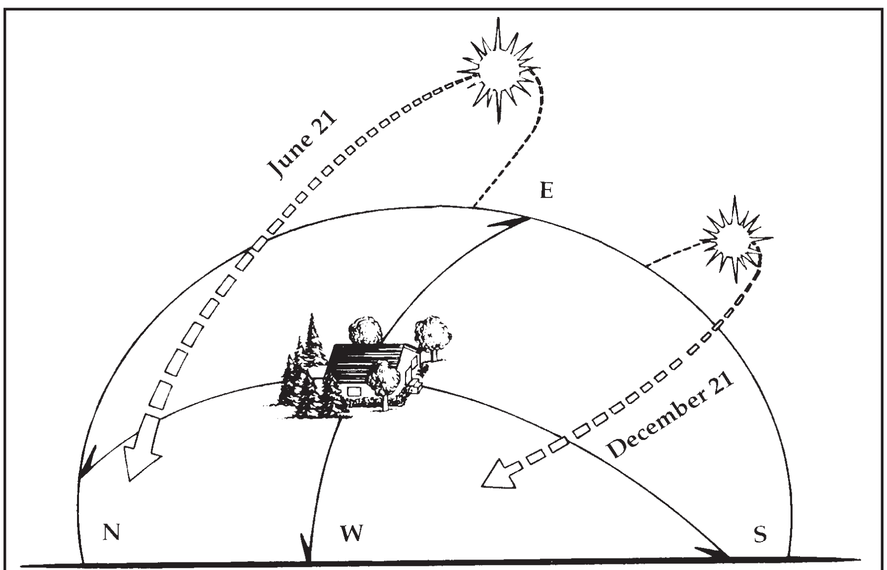
- Go easy on hot water – it produces both heat and humidity.
- Use kitchen and bathroom exhaust fans when cooking or bathing to remove unwanted moisture quickly. (See sidebar, Combustion Air)
- Reduce the use of artificial lighting (especially incandescent) because lights produce heat.
- Avoid using the dry cycle on your automatic dishwasher; allow dishes to air-dry instead.
- Make sure your clothes dryer is vented to the outside.
- Increase natural ventilation in the attic by opening attic windows or louvers.
- Drink plenty of cool liquids – they really do help keep you cool.

All of the above measures to reduce heat – from the sun's rays, air infiltration, or indoor activities – can be applied even if you have air conditioning, since they will cut operating costs.

Cooling with fans

Fans cool through circulation and ventilation. Circulating air increases the evaporation of perspiration from your skin, which is why it feels good to sit in front of a fan. In cooling a large space, however, it is more effective to use fans for ventilation.

Figure 1.
The seasonal path of the sun has a major effect on home heat gain.



Portable window fan. For about $30 you can create cross ventilation with a portable window fan, making this an excellent and inexpensive cooling method, especially during the night or after a rain storm when the outside air is cooler than indoors. Place the fan in a window on the coolest side of the house, using it to pull cool air in and push hot air out through open windows on the warm side of the house. When used correctly, window fans can cool several rooms at once. One caution: using a fan to push air out of the house can create negative air pressure in the house, leading to backdrafting. (See sidebar, Combustion Air)

A ceiling fan is quieter than a portable fan and is safely out of the reach of children. When used along with air conditioning, ceiling fans circulate the cooled air effectively, making the space feel cooler. This may allow you to set your thermostat a few degrees higher, thereby saving energy and money without sacrificing comfort. The table below will help you choose the correct size ceiling fan. Fans should have multiple speed settings so that air flow can be reduced at lower temperatures.

Ceiling Fan Sizing

Room area (sq. ft)	Minimum fan diameter (inches)
100	36
150	42
225	48
375	52
400+	2 fans

A whole-house fan is no longer recommended. Cutting a hole in your ceiling to install the fan often creates another "attic bypass" or source of heat loss in the winter, since it is very hard to seal around the fan. Whole-house fans also may create negative pressure in your house which can cause harmful backdrafting of appliances. (See sidebar, Combustion Air)

Attic fan. Using an attic fan (which is not the same as a whole house fan) to cool your house is of doubtful value. The fact is, there should not be any active relationship between the attic air and the air in your living space. It is true that adding an attic fan will help pump hot air out of the attic, lowering the attic temperature and perhaps reducing heat in the top floor of the home; however, because most homes have some attic bypasses (openings through which air from the living space leaks up into the attic), the fan will pull cool air through the insulation, which could lead to backdrafting. (See sidebar, Combustion Air)

Although attic fans are not generally recommended, attic vents *are* recommended. They help keep the attic cooler above the insulation and reduce moisture in the winter. If your attic has a vapor barrier, one square foot of outside ventilation should be provided for each 300 square feet of attic area. If there is no vapor barrier and the roof has less than a three-foot rise from eave to peak, one square foot of ventilation is needed for each 150 square feet of attic floor space.

Room air conditioners

Those who want more cooling than the above measures provide will look to air conditioning. One option is to purchase a room air conditioner to fit in a window or wall.

Sizing. Oversizing is the most common mistake made by shoppers, who think that “bigger is better.” In fact, buying too large a unit is not only expensive, it can increase discomfort by not removing enough humidity from the air, leaving you feeling cold and clammy. An air conditioner’s primary tasks are to cool and dehumidify, but a typical unit is much more efficient at cooling. Since the major control in an air conditioner is a thermostat, not a humidistat, the unit comes on and shuts off in response to air temperature, regardless of humidity level. A system that is too large often achieves the desired temperature before the humidity is adequately removed. If a system is too small it may dehumidify well, but not cool the air sufficiently. In a properly sized unit, the operating cycle should be long enough to remove heat and humidity.

Air conditioners are sized according to Btus of heat removed per hour, or in “tons” of refrigeration, with one ton equaling 12,000 Btus per hour. The load on the unit determines the size you need. The load has two parts: the energy it takes to cool the air (sensible load) and the energy required to dehumidify (latent load). Together, the sensible and latent loads total 100 percent of the air conditioner’s load.

Your first step is to carefully determine the size of the area to be cooled, making sure to close off unused rooms or areas where cooling isn’t necessary. As a rule of thumb, based on size alone, an air conditioner should have 20 Btus for each square foot of living space. Keep in mind, however, that this formula is simply a rule of thumb. A number of factors, such as the amount of shade around your house, window area, amount of insulation, or the size of your family means that you may have to go one size larger or smaller.

Efficiency. All new room air conditioners are required by law to carry an Energy Guide label showing the energy efficiency ratio, or EER. This bright yellow label lists the EER and compares it to the EER of models with similar features. The higher the number, the more efficient the appliance. The Energy Information Center recommends purchasing a model with an EER of 10 or higher. The Energy Guide label also lists the average yearly operating cost, based on average electric rates.

Wiring requirements. Since air conditioners consume large amounts of electricity, they may require too heavy a load for some circuits. Make sure the unit you buy will not cause an overload. In some cases you may need a special circuit with a separate fuse. Newer homes built to newer building codes have at least 100 ampere, 220 volt service, but many older homes have only 30 ampere, 110 volt service. Be sure to ask an electrician about the adequacy of your home wiring.

Installation. Always follow the manufacturer’s instructions, since each unit has its own specific installation requirements. Location is also a key factor in operating efficiency. Ideally, window units should be placed in the middle of the area to be cooled and on the north or shady side of the house. Do not obstruct the free flow of air around the unit.

Operating tips for maximum efficiency include:

- Use a table or wall thermometer as a guide in selecting the air conditioner setting (room air conditioners don’t come with thermostats calibrated by degrees). Keeping the indoor temperature within 17 to 20 degrees of the outdoor temperature on extremely hot days is important. You will be cool and at the same time save

Combustion Air – A Concern Year-round

All fuel-burning appliances need a supply of fresh air for the combustion process; a shortage of fresh air can cause the appliances to backdraft dangerous gases – including deadly carbon monoxide – into the home.

Although a shortage of combustion air is often associated with the heating season, when houses are shut tightly against the cold, backdrafting can – and does – occur year-round. Following are precautions which apply specifically to summer cooling practices.

Using fans to exhaust air from inside the house can create negative air pressure, resulting in backdrafting of a fuel-burning appliance – most often the natural gas water heater. Open windows may not provide a sufficient amount of make-up air for the fan. Attic exhaust fans also pose a problem, since standard passive air vents into the attic do not supply sufficient make-up air. The result may be the suction of cool air from inside the home up into the attic, possibly creating negative pressure in the home and the potential for backdrafting.

(con't next page)

energy and avoid overworking the unit to the point where it may break down.

- Check the filter once a month and clean as needed. Usually the filter is located just behind the front grill and many are washable. A dirty filter can significantly reduce the efficiency of the unit.
- Set the fan speed at low or medium, if you have the option. That will move the air across the cooling coils more slowly, enhancing dehumidification.
- When you turn the conditioner on, don't set it on the coolest setting thinking that the room will cool off faster – it won't.
- Keep windows and doors closed to block the infiltration of hot air; remember, the more space you cool, the more electricity you use. If the air conditioner has the capacity to cool more than one room, but you are using only the room it is in, close the doors to connecting rooms.
- Avoid blocking air circulation with furniture or draperies placed in front of the conditioner.
- Clean the condenser (the outdoor section of the unit) every year, removing dirt, leaves, grass, and the like. Your owner's manual should provide cleaning instructions.
- Install a timer to automatically control operating times so that the conditioner does not run while you are away from home. Timers can be bought at most hardware stores for $10 to $30.

Central cooling

Central air conditioners are designed to cool, dehumidify, and filter the air throughout your house. Generally, these systems are more expensive and use more energy than room air conditioners, but the costs can be minimized by following the same guidelines as for room units: buy the right size, choose a high efficiency unit, locate the unit properly, and maintain it well.

Sizing. Central air equipment is usually purchased through a heating/air conditioning contractor who is responsible for calculating what size unit you need. Ask your contractor if he or she is using the sizing guidelines described in "Manual J" (available from the Sheet Metal Air Conditioner Contractors' Minnesota Association, phone 612-593-0941). Make sure the following factors are considered in the sizing calculations:

- Size of area to be cooled.
- Amount of insulation in the attic and walls.
- Tightness of the home: very leaky, average, or very tight.
- Window area, particularly on the south, west, and east sides of the house. The larger the window area, the greater the solar heat gain. Also consider whether the windows have double

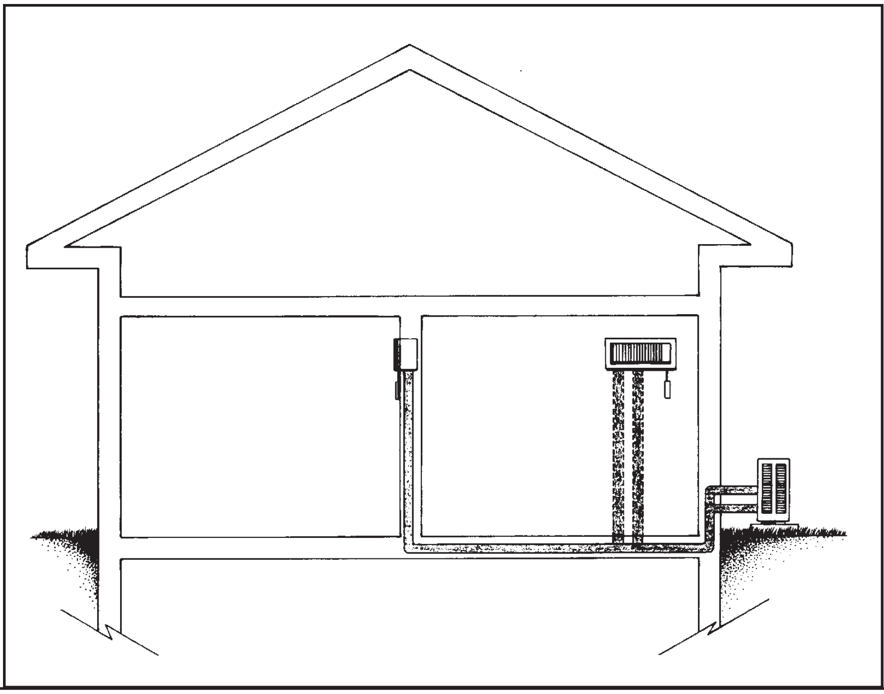


Figure 2.
A ductless system provides quiet room cooling with wall mounted units and an outdoor condenser.

panes, low-e coatings, and other features that enhance efficiency.

- Orientation of the house. A sunny exposure requires a bigger unit, especially if the windows are not shaded.
- Amount of shade. Trees, fences, shrubs, and other landscaping features, as well as window shades, may reduce heat gain.
- Family size and lifestyle. Larger families release more heat energy into the house from body heat and activities such as showers and cooking.

Also, make sure your house has the proper wiring. Central air conditioning requires a separate circuit and is operated on 220 volts.

You should obtain bids from at least three contractors, not only to compare costs, but also to make sure that you are getting the right size unit. The size estimations should be fairly close; if they are not, find out why.

Efficiency. After you determine the proper size, compare efficiency ratings of different models with the same capacity. Even though the more efficient unit may be higher priced, it is usually the best buy because high efficiency units cost less to operate. Central air conditioners are rated according to their Seasonal Energy Efficiency Ratio, or SEER. The Energy Guide label lists the SEER and compares it to SEERs of similar models; it does not, however, list an annual estimated operating cost. The Energy Information Center recommends buying a central air system with a SEER of 12.5 or higher.

Installation. The installer should always follow the manufacturer's instructions. Location is also important. If possible, place the condenser on the north or shady side of the house. Always make sure to allow for plenty of air circulation around the condenser.

Operation and maintenance. To improve efficiency and keep equipment running smoothly, follow these guidelines:

- Replace or clean filters monthly.
- Remove dirt and dust from outside coils and fins.
- Keep all return and supply registers clean and unobstructed by furniture and draperies.
- Install a setback thermostat that will turn the air conditioner on one hour before you come home each day.
- Have a qualified service person tune-up the system at the same time as the furnace tune-up is done.

Types of central air systems

Described below are the major types of central cooling systems used in this area. They provide the same benefits, but differ in configuration. The traditional type, generally costing around $1,600, uses the same ducts and registers as a forced air heating system. The ductless systems range in cost from $2,500 to $5,000 installed and are basically a combination of room and central cooling, offering an alternative for homes without ducts and registers. A third type, heat pumps, costs $2,000 or more and both cools and heats the home through a two-way heat transfer system using air, water, or ground. Ground-source heat pumps use the ground as the heat source/heat sink, depending on the season, and operate with great efficiency. Although the purchase price is high, these pumps may be cost effective in many installations.

Traditional, or forced air system, is the most common in our area and the likely choice if you have a forced air heating system. The condenser unit is outside, while the evaporator (the cooling component) is installed in the furnace. The same duct work used for heating is used to distribute cool air throughout the home. (Home owners should be aware that leaking air ducts affect efficient distribution of cooled air, as well as pose a potential backdrafting problem. See sidebar on Combustion Air).

Ductless systems are appropriate for homes with hot water or steam heat or those divided into separate areas (see Figure 2.) This type of system distributes cool air to selected portions of the home without the need for ductwork. Instead, small diameter tubes (5/8 to 7/8 inch) run between the outdoor condenser and the indoor wall-mounted unit, forming a closed loop system. The cooling component(s) is mounted on the wall of one, two,

Combustion Air (Con't)

Central air conditioning, forced-air systems, also present a potential backdrafting problem. Leaks in return air ducts have been identified as a cause of backdrafting year-round, since they add to air depressurization in the basement. In addition, they lead to inefficient and ineffective cooling. This is how it works: When the air conditioner runs, cool air leaks out of supply ducts and sinks to the lowest level of the house. In addition, leaks in return ducts draw cool air back to the central air conditioner coil before the cool air ever reaches the upper floors. The result of both supply and return duct leaks is a cold basement and difficulty in keeping the rest of the house —especially the upper floor — sufficiently cool. This, in turn, leads to the air conditioner being run longer, resulting finally in higher energy costs.

For more information on combustion air problems and leaking air ducts, call the Energy Information Center and ask for the publications Combustion Air and Duct Sealing.

The CFC Dilemma

CFCs (chlorinated fluorocarbons), a commonly used refrigerant, have been identified as a major factor in depleting the earth's protective ozone layer. By international agreement, CFCs are being completely phased out. Alternative refrigerants comparable to CFCs in safety, cost, and efficiency, but without their harmful effects, are available in some models. Ask your dealer for details on the air conditioner you are considering.

or three rooms and resembles a room air conditioner, but is much quieter. The condenser is installed outdoors, like that of any central air conditioner. Some ductless systems will support multiple terminals having a total cooling capacity equal to traditional forced air systems. An advantage of the ductless system is the easy ability to "zone" or cool only those areas in the home you are using. Other systems require additional investment for the ability to zone.

A high velocity system is another option, especially attractive to those who want central air conditioning but do not have a forced air distribution system. The high velocity system uses smaller ductwork, sometimes flexible insulated duct. Main trunks may be only six inches in diameter, with delivery ducts possibly only three inches in diameter. The ducts are supplied with air from an air handler using a higher velocity fan. The air conditioning cooling coil is installed within the air handler. The smaller flexible duct allows for smaller openings in walls and ceilings. Proper sizing of cooling equipment is always important, but it is critical with high velocity equipment.

Heat pumps in general can be used successfully in Minnesota – with certain conditions. A heat pump looks and operates like a central air conditioner, but it can be used for heating as well as cooling. During the heating season, the heat pump extracts heat from the outside air (or from a water supply or the ground) and brings the heat into the house where it is distributed through a duct system. In the summer, the heat pump cools the house by moving heat from the inside to the outside air (or water or ground) using a basic closed loop refrigeration cycle. In Minnesota, air source heat pumps are used for whole house cooling, but must be supplemented by another heating system during the winter.

Currently, the most effective type of heat pump for our climate is the ground-source system which uses the earth as its heat source in the winter and as a heat sink in the summer.

Ten Common Questions and Answers

Following are answers to the 10 most-often-asked questions on cooling received by the Energy Information Center.

What size air conditioner should I buy?

"Smaller is better" is the rule to follow for residential users. Smaller units run in longer cycles, which is better for humidity control and efficiency.

How important is efficiency? Is it worth the extra money?

Even though efficient units cost more initially, they cost less to operate, so you save money over the life of the unit. For example, choosing a room unit with an EER of 11 rather than 9, will save you 18 percent a year. Also, keep in mind that many utilities offer rebates if you purchase high efficiency air conditioners.

Can I cool the house with two room air conditioners?

Maybe, but it may not be cost-effective. Although fans can help circulate the cool air to other rooms, electrical costs can quickly exceed those of a central air system, so make sure to weigh cost and benefit. If you choose to cool with multiple room units, close off unused rooms and size the units according to the entire space to be cooled. Don't expect a unit designed to cool a single room to be able to cool a number of rooms adequately.

What is the latest advance in residential air conditioners?

Major manufacturers of residential central air conditioners make and market "scroll" condensers in two- to five-ton sizes. Scroll condensers have fewer moving parts than the traditional rotary condenser. They come with SEERs of 10 to more than 13.

How much will it cost to operate an air conditioner?

Operating costs are determined by the size of the unit, its efficiency, and the cost of electricity.

A typical 30,000 Btu (2-1/2 ton) central air system with a SEER of 10 will cost about $.21 (at $.07 per kWh) for each hour of condenser operation. This equals $137 for 650 hours of cooling in a typical Minneapolis/St. Paul summer. A typical 8,000 Btu room air conditioner with an EER of 9 will cost $.08 per hour, or $52 for the summer.

Does my air conditioner need to be "tuned?" If so, what should the service person do?

Yes, your air conditioner should be "tuned" regularly. Hire a professional service person every two years to do the following:

- Clean the interior and exterior coils (dirt and dust act as unwanted insulation, making the necessary heat transfer difficult).
- Check the amp drawn by the unit to see that it does not exceed the manufacturer's rating.
- Check the belts, bearings, and electrical connections, adjusting as needed.
- Check for refrigerant leaks and add if needed. If your unit has a leak, make sure your contractor collects and recycles the refrigerant.

What should I look for in my warranty?

Look for the following three points:

- Parts include all the electrical components, typically covered for one to two years, and coil, typically covered for five years perhaps as much as ten years.
- Condenser, typically covered for five years but may be as much as ten years for high efficiency condensers.
- Labor, which varies from contract to contract, so look for any limitations in labor cost coverage.

Many utilities offer a service contract for parts and labor that may be more useful than an extended warranty. Also keep in mind that a longer warranty may not mean that the equipment is better, only that it is more expensive.

Can I cool off by putting ice in a large bowl and blowing a fan across it?

In the short term, yes; in the long term, no. The melting ice absorbs a lot of heat from the air while the evaporating water adds humidity. Consequently, you are merely changing the form of discomfort.

If you put ice in a sealed container such as a gallon glass jar with a tight fitting lid, you can cool off with a fan blowing across the jar and at the same time keep the humidity out of the surrounding air.

Is it better to have my window fan blowing into or out of the house?

Place the fan so that it blows cool air into the room.

Will an attic fan make my home cooler?

Perhaps, but only the top floor. Attic fans pull hot air out of the attic, decreasing the amount of heat coming through the ceiling but also increasing your electric bill.

Super Saver Switch

"Super Saver Switch" and similar programs have become popular among residential electric customers using air conditioning. These programs offer customers substantial discounts for allowing the utility to control their air conditioners during periods of high demand. The utility cycles the condenser off and on in a manner that allows for comfort and at the same time alleviates pressure on the utility's generation capacity. Contact your utility about the availability of such a program.

One caution is needed for homes in which the central air conditioner uses the same duct system as the heating system. For those who do not have a sealed combustion furnace, the combustion air supply for the furnace is often brought into the home through the cold air return line. When the condenser is shut off by the utility, the furnace fan, which brings in the combustion air supply, continues to run. As a result, warm moist air is drawn in through the combustion air supply, increasing temperature and humidity in the home. Consumers with this arrangement should consider changing the combustion air supply system to one which brings the air to the furnace area. The Home Energy Guide, Combustion Air, describes how this can be done.

HOME ENERGY GUIDE

TECHNIQUES TACTICS & TIPS

New Homes

Minnesota Department of Commerce Energy Information Center

A new home is the most important purchase most of us will make in our lifetime. When we buy a new home, we want to accomplish several goals, all of them critical to our well-being.

- **We want our new home to provide a comfortable and healthy environment.**
- **We want our home to be efficient and economical in its operating expenses, free of exorbitant energy bills, costly repairs, and other maintenance costs that could have been prevented during construction.**
- **We want our new home to be durable, providing good return on our financial investment when it comes time to sell.**

An energy efficient home is designed to accomplish these goals. It is built on the principles of building science, which recognize that the home is a system consisting of the building structure, the mechanical systems, and the occupants. Over the past two decades, studies of cold climate housing have taught us how these three elements interact, and how the new home and its mechanical systems should be designed to achieve the goals described above. We know, for example, that air tightness increases energy efficiency, comfort, and durability at the same time it requires that outdoor air be brought in to provide healthy indoor air and control moisture. The amount of outdoor air required depends on the number of human occupants, their activities, the location of the home (whether the site is moist or dry), and the kinds of mechanical systems in the house.

This guide is designed to help buyers of new homes understand these basic building science principles and how they affect construction details and the selection of heating, ventilating, and other mechanical systems. It gives new home buyers the information they need to discuss intelligently with the builder the various options for achieving an efficient, durable, and healthy home. Finally, it helps them understand the importance of the home owner's role in furnishing, maintaining, and operating such a home.

Essential Components of an Energy Efficient Home

Three important characteristics distinguish an energy efficient, high quality home: lower energy use, moisture control, and indoor air quality control. These qualities are interrelated. To ensure that all three qualities are present, the new home requires several key components, and these, in turn, require attention to construction details. The components are described below. Discuss them and the construction techniques used to implement them with your builder. Also ask about having a blower door test performed on the newly constructed home to verify air tightness. More information on the various components of an energy efficient home is available in the books and materials listed in the bibliography.

Related Guides:
Home Insulation
Home Moisture
Windows & Doors
Home Heating
Home Cooling
Wood Heat
Combustion Air
Indoor Ventilation
Appliances
Lighting

New Home Warranties

Minnesota law requires builders to warrant that the new home will be:

- Free of major construction defects for 10 years. "Major construction defect" means damage affecting the stability and safety of the dwelling. It does not include damage caused by flood, earthquake, or other natural disaster.
- Free for two years from mechanical defects caused by faulty installation of plumbing, electrical, heating, and cooling systems.
- Free for one year from defects caused by faulty workmanship and defective materials.

Some builders enroll in special new home warranty and insurance plans that cover liability for major structural defects. Although the cost of these plans can add to the cost of the home, they are a protection to the consumer and are especially helpful to the new builder in establishing credibility.

Full coverage, optimal thermal insulation

In Minnesota, with its long and cold winters, heating accounts for the major portion of a home's annual energy use. Keeping the same space cool in summer also accounts for a significant – and increasing – portion of home energy use, as air conditioning becomes more widespread. An energy efficient home, therefore, relies on having an outer structure – or thermal envelope – that is tight and well insulated, that reduces air flow and heat transfer between the indoors and outdoors in both summer and winter.

Thermal insulation reduces heat transfer. The ability of insulation to resist heat flow is expressed in terms of R-value: the higher the number the greater the resistance. The R-value of insulation varies according to the thickness of insulation and its material. The Minnesota energy code establishes minimum R- values for foundation walls, exterior walls, and the ceiling/attic floor, but various methods and techniques are available for easily achieving higher than minimum R-values. Some of these options are described below; talk to your builder about these or other ways to achieve optimal thermal insulation.

- On foundation walls, the Energy Information Center recommends at least an R-10. A common practice for achieving a minimum R-5 is to place rigid insulation on either the interior or exterior of the foundation walls. An easy way to increase this R-value to 10 is to install additional insulation on the interior side. If the foundation is concrete or masonry block, builders often construct an inner stud wall which is fitted with batt insulation, or they apply foam plastic insulation right to the concrete wall and cover it with sheet rock.
- On walls: Adding rigid insulation over an insulated frame wall built with the industry standard 2 x 6 inch studs increases the minimum 19 R-value to a recommended 24. Discuss this option with your builder.
- On ceilings/ attic floor: To increase the R-value beyond the required 38 minimum, simply add more insulation. For vaulted ceilings, increase the framing depth to allow for more insulation or install foam sheathing on the underside of the vault.

Full coverage is as important as the insulation R-value. Any part of the house that is heated should be separated from the unheated space by an insulation barrier. Some areas needing special attention include:

- Basement floor. An uninsulated floor is cold and may be damp; an insulated floor is warm and dry. The Energy Information Center strongly recommends insulating the basement floor. A one-inch thick rigid insulation, separated from the slab by a few inches of gravel, can be used. Some heating systems use the basement slab or sand underneath the slab for heat storage. In this case, extra insulation is strongly recommended: two-inch thick rigid insulation surrounding the heat storage system is recommended.
- Crawl spaces beneath heated spaces. To control moisture, a polyethylene moisture barrier should be placed over the entire ground and extended up four to six inches on the crawl space walls and sealed to the walls. The walls of the crawl space can be insulated with batts or with rigid insulation placed either on the exterior or or interior of the walls (See Figure 1).
- Attic insulation should extend to the outer edge of the outside wall. (An energy truss allows a full depth of insulation to extend to the outside of the wall. See Figure 6.)
- The rim joist where the exterior framing meets the floor joists is a critical area to insulate and air seal, and it is often a major source of heat loss. One way to handle the problem is to first seal the rim joist against air leaks and then insert pieces of rigid insulation between the joists, covering them with sheet rock to meet fire protection standards (See Figure 2). The rim joist can also be insulated on the exterior. Discuss this with your builder.
- Other problem areas – cathedral ceilings, floor overhangs, and split level homes – are described in greater detail in the insets in this guide.

Continuous, interior side air barrier and vapor retarder

Insulation resists heat transfer, but it only slows – does not stop – air movement. Warm air moving through the insulation results in heat loss in winter and unwanted heat gain in summer, increasing year-round energy costs.

More important than the heat loss, however, is the moisture that the warm air carries into the insulation and onto the building framework. Moisture substantially reduces the effectiveness of insulation and also can result in mildew and mold growth and rot of building materials.

Leaking air is also a major cause of ice dams on roof eaves. Warm air leaking up into the unheated attic through electrical openings and other gaps in the air barrier creates warm spots on the roof, starting the snow melt that eventually leads to damaging ice buildup along the eaves.

Movement of warm air from the heated space into the building envelope is the largest potential source of heat loss and moisture problems, and for this reason a continuous air barrier must be installed on the warm or interior side of the insulation. Since moisture can also penetrate by diffusion, a vapor retarder must be installed on the interior side of the insulation. In most new homes, the air barrier and vapor retarder are one and the same: a polyethylene sheet installed on ceilings and walls. An alternative to this standard air-vapor retarder is the airtight drywall approach (ADA). ADA uses the drywall itself, along with caulking, sealants, adhesives, and gaskets, in various combinations, to achieve the required air barrier. A vapor retarder is still required. This can take the form of a coat of vapor retarder paint or a foil backing applied to the drywall, or most commonly it can be a separate polyethylene sheet.

The critical requirement of the air barrier/vapor retarder is that it be continuous; any breaks result in loss of heated moist air and moisture penetration into the building envelope. Providing continuous coverage with an air barrier/vapor retarder requires attention to details. Electric wiring, plumbing, and other penetrations into the air barrier/vapor retarder are inevitable. The solution is to seal all these openings, using either caulks and foams, gaskets and adhesives, blocking and tapes, or all of these, depending on the size and location of the penetrations. Special attention must be paid to ensure that air sealing occurs at each step of construction. Discuss these details of construction with your builder and ask that a plan be developed to ensure sealing the air barrier/vapor retarder. Discuss the builder's quality control program to ensure sealing of the air barrier. Mention specifically the following areas:

- Areas difficult to insulate, described in the section above and also in the "Design Details" insets in this guide. These areas are also difficult to protect with a sealed air barrier.
- Electrical, plumbing, and telecommunication outlets and other penetrations into the exterior wall and ceiling air barrier.
- Tubs and showers located on exterior walls.
- Fireplace enclosures.
- Recessed light fixtures. These are a major source of air leaks. Talk with the builder about the importance of inspections or other quality control measures to ensure air sealing.
- Ductwork. (It is preferable to have all ductwork run inside the insulated envelope and sealed throughout.)
- Air leakage from the garage. Ask your builder how air from the garage will be prevented from leaking into the home.

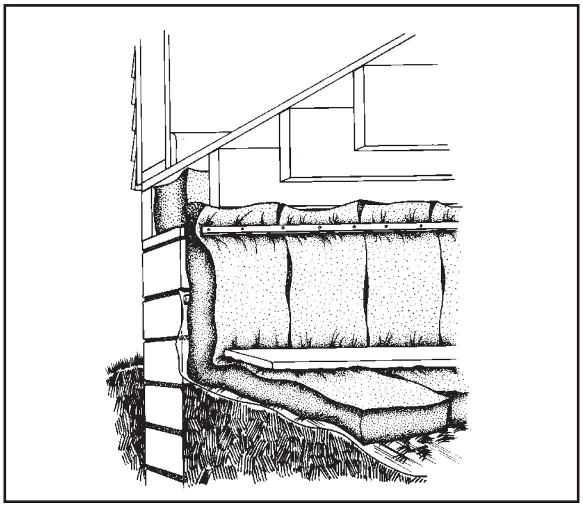


Figure 1
To control moisture in a crawl space, a polyethylene moisture barrier should be placed over the entire ground and extended up at least four to six inches on the crawl space walls and sealed to the walls.

A New State Energy Code

Effective April 15, 000, new energy code rules go into effect as part of the state building code. The new code incorporates the principle of "build tight and ventilate right." It recognizes that the home is a system, consisting of the building structure, the mechanical systems, and the occupants. The new code takes into account the need for air tightness to ensure comfort and energy efficiency, and also the need for mechanical ventilation to control moisture problems and provide proper amounts of fresh air for the occupants.

The new standards give Minnesota the most advanced energy code in the nation. Considerable effort is required to fully and effectively implement the code, and new home buyers are advised to consult with their builder and work out a plan for informing all subcontractors of the construction details required.

New home buyers should also be aware that they have many options for going beyond code requirements and achieving even higher levels of energy efficiency, comfort, and durability. Many of these options are described in this guide.

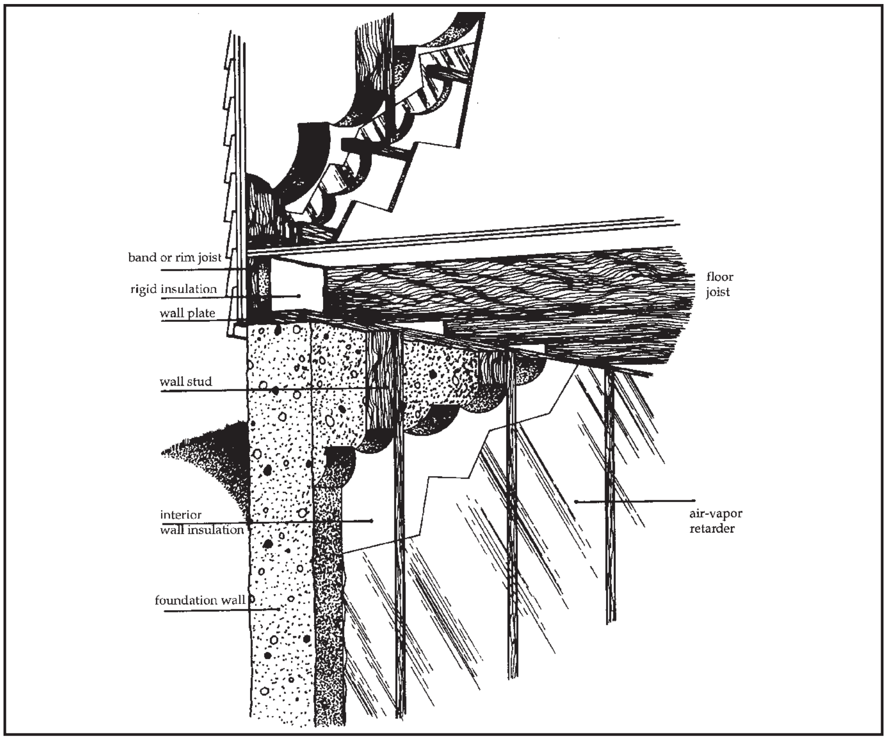


Figure 2
To maintain a continuous air-barrier and vapor retarder at the basement/first floor juncture, the air barrier/vapor retarder covering the inner walls is sealed to the basement wall plate and first floor sillplate, and pieces of rigid insulation are inserted between the floor/ceiling joists. Cut-away section reveals various wall components.

nfrc National Fenestration Rating Council Incorporated
CERTIFIED

AAA Window Company

Manufacturer stipulates that these ratings were determined in accordance with applicable NFRC procedures.

Energy Rating Factors	Ratings Residential	Ratings Nonresidential	Product Description
U-Factor Determined in Accordance with NFRC 100	0.40	0.38	Model 1000 Casement Low-e = 0.2 0.5" gap Argon Filled
Solar Heat Gain Coefficient Determined in Accordance with NFRC 200	0.65	0.66	
Visible Light Transmittance Determined in Accordance with NFRC 300 & 301	0.71	0.71	

NFRC ratings are determined for a fixed set of environmental conditions and specific product sizes and may not be appropriate for directly determining seasonal energy performance. For additional information contact:

Figure 3
Look for the NFRC label providing information on the U-value rating of the window unit. Within a few years, most doors also should carry this rating.

Continuous exterior side air barrier

Insulation and the building framework must also be protected from exterior wind and water. A number of methods and materials can be used, including building sheathings (including some rigid foam insulations) that are impervious to water and air and a sheet of flexible material resistant to water and wind penetration that is placed around the exterior of the building between the sheathing and siding. Some products/materials can serve multiple purposes. A spray foam insulation, for example, may serve as insulation, an exterior air barrier, and an interior air barrier as well.

A separate air barrier is especially critical at the top of exterior walls, where the attic/ceiling insulation extends to the outer edge of the wall frame. Install air chutes or baffles and wind wash barriers at soffit vents to prevent air from penetrating the insulation (see Figure 6).

Energy efficient and condensation resistant windows

Window thermal performance has improved dramatically in recent years. Low-e coatings on glass panes, gas fillings and insulating spacers between panes, and improved framing materials all reduce heat loss in winter and heat gain in summer. In addition to increased comfort and reduced energy loss, a further advantage of these high performance windows is less moisture condensation: greater insulating ability results in a warmer temperature for the windows' indoor surface, resulting in less condensation.

In selecting windows for your new home, look for the label with the National Fenestration Rating Council (NFRC) U-value (or the equivalent for imported windows). The lower the U-value the better the insulating ability. The NFRC U-value rating is on the whole window unit – glass panes and frame – and this is an important distinction. A double-paned window with low-e coatings and gas fillings, for example, might have a center-of-glass U-value of 0.25, but an overall U-value of only 0.34.

Air tightness is another characteristic of an energy efficient window. Make sure the window has durable weatherstripping. Window manufacturers provide results of standard air infiltration tests. The Minnesota energy code sets a maximum infiltration rate of 0.37 cubic feet per minute per linear foot of sash crack (where the sash meets the stationary frame).

Window style or design is not a major factor in efficiency.

Window installation is still another important factor in energy efficiency. Even the highest quality window loses effectiveness if there is heavy air infiltration between the rough framing and the window. Simply stuffing fiberglass into this area is not adequate. Sealing the gap between the rough opening and the window is critical.

- Make sure the builder sizes the rough opening large enough to allow for installing an airtight seal between the window frame and the rough opening.
- Discuss with your builder the various techniques that can be used to achieve quality installation, including an airtight seal and the kind of quality control measures the builder uses to ensure this seal.

Doors also have improved in efficiency; metal and fiberglass doors with cores of insulation now account for about half of all doors in newly constructed homes. Metal and fiberglass doors provide better insulation and security than patio sliding or French doors. Glass patio doors have considerably less insulating value than insulated wood or steel doors. If you plan to have glass doors, ask your builder to use doors that have an NFRC low U-value rating. The NFRC rating for doors began only recently, but within a few years most doors should carry this rating.

Air tightness is as important for doors as for windows. Key factors are good quality weatherstripping and careful sealing of the wall air barrier/vapor retarder to a polyethylene strip wrapped around the door frame. Ask your builder about cold weather performance of the weatherstripping.

Effective ground moisture/soil gas control

Except for structural errors, moisture damage is the nation's leading cause of problems in buildings. And in Minnesota, these moisture problems often begin with a damp or wet basement. Studies show that 10 gallons or more of water vapor per day can evaporate into a house through the basement walls and floors.

The Energy Information Center recommends the following measures:

- The first and perhaps most important step is to select an appropriate building site. A site with a high water table presents substantial obstacles to building and maintaining a dry basement.
- The state building code requires that landscaping be appropriately graded to direct rain water and melting snow away from the foundation. Because the backfill always seems to settle after a year or two, it is important to start with a generous slope: The Energy Information Center recommends at least six inches over the first ten feet from the foundation wall.
- A high quality, durable coating – termed waterproofing – should be applied on the below grade portion of foundation walls. This provides better protection from moisture penetration than the building code's minimum requirement of a dampproof coating.
- Use gravel as backfill around the foundation. Cover it with a low permeability soil or hard surface to divert runoff away from the foundation. Porous backfill gravel or sand should be used against the foundation walls to promote drainage to a channel of coarse rock or drainage tile located outside the foundation footing. A drainage mat product can be used in place of – or in addition to – the backfill gravel or sand. Drainage mats made of corrugated fiber or plastic material create a clear drainage path directing water to the drain tile.
- The concrete slab floor should be poured on top of three to four inches of washed aggregate, with a sheet of polyethylene underlying the aggregate. Insulating under the aggregate with rigid insulation replaces the need for the polyethylene sheet.
- Heated slabs, with heat pipes or cables either embedded in or below slabs, should be protected on the sides and bottom by R-10 insulation.
- Heating system ducts should not be installed in the ground below a slab. In an energy efficient home, it can be appropriate to locate heating duct outlets on interior walls.

Design Details: Skylights

Skylights are a weak area in the thermal envelope; their insulation value is low and they create breaks in the air barrier. Their location at the top of the thermal envelope makes condensation problems and potential air leaks even more serious. Care must be taken to install the skylight so that it is sealed tightly to the air barrier/vapor retarder. Designing and installing the skylight so that snow is shed readily helps prevent problems with snow melt. Look for skylights with an NFRC overall U-value of 0.55 or less, and a shading coefficient of 0.5 or less.

Design Details: Fireplaces

Open hearth or conventional fireplaces are popular, but since they require large amounts of combustion air, they significantly affect the air supply in the home and make it essential to have only direct vent combustion furnace and appliances. A direct vent gas fireplace is fully compatible with an energy efficient home.

- Many homes in Minnesota are now constructed on a concrete slab (slab-on-grade), with no basement. Avoid placing a forced-air heating system below a slab-on-grade. The Energy Information Center recommends that insulation be placed around the perimeter and beneath the entire concrete slab.

Safe, efficient space heating, cooling, and water heating

Space heating is the prime energy user in a Minnesota home. Reducing this energy use and its cost is the principal reason – along with increased comfort – for building an energy efficient home. An important factor in achieving maximum efficiency is the selection of an efficient heating system.

Combustion heating system. A combustion (fuel burning) furnace or boiler requires air (called combustion air) for proper operation. For this reason, it is extremely important to buy a direct vent (sealed combustion) furnace. This type of furnace brings air from outdoors directly into the combustion chamber without mixing it with indoor air, and it discharges all flue gases directly to the outdoors. This type of furnace does not require a chimney, so you'll have greater freedom in where to place it and also save chimney construction costs. The air tightness of a well insulated home also makes it possible to buy a smaller size furnace than otherwise would be needed. An additional advantage of a forced air heating system is that its ductwork can be used by a central air conditioner.

The Annual Fuel Utilization Efficiency (AFUE) for a furnace is like the miles-per-gallon label on a new car. This rating estimates how much of the fuel used actually goes into heating the home, based on average use. A national efficiency standard for furnaces took effect in 1992, requiring that each furnace have an AFUE of at least 78 percent. This minimum rating is expected to rise in the near future. New efficiency models have AFUE ratings of 90 percent and higher, and the Energy Information Center strongly recommends selecting one of these models for an energy efficient home.

Choosing the appropriate size furnace also is important: oversized furnaces, because they cycle on and off more frequently, are less efficient. Your builder can provide a good estimate of what your annual heating and cooling needs will be.

Annual energy costs also are affected by the amount of electricity a fuel-burning furnace uses to circulate air. Variable rate furnaces use considerably less electricity – as much as 50 percent less – than other forced-air furnaces. Features include microprocessor controls, which automatically adjust air flow to achieve maximum efficiency.

Electric heating systems. Coefficient of Performance (COP) measures the efficiency of electric heating. A COP of 1.0 means that the heat energy the appliance delivers is the same as the electrical energy it uses. Although all electric heating systems operate at nearly 100 percent efficiency and therefore have a COP of at least 1.0, this rating does not take into account the energy used to generate and transmit the electricity.

- Baseboard electric heaters, radiant ceiling and wall panels, in-floor radiant heating, and electric furnaces all operate at 100 percent efficiency (COP 1) and, with the exception of electric furnaces, are easily zoned to provide different levels of heat in different rooms. At current prices of electricity, however, they also are probably more expensive to operate than oil, natural gas, or propane furnaces. In some areas of Minnesota, electric utilities provide discount rates for energy used during off-peak hours (usually later at night and in the early morning). Customers can take advantage of these rates if they have a backup fuel source such as fuel oil or propane or have an electrical thermal storage system. These systems consist of heating elements and some type of heat storage unit (such as rock, water, or ceramic materials).

- Air-source heat pumps extract heat from the air and will not perform well over extended periods of sub-freezing weather; for that reason they are not suitable for the Minnesota climate without a backup system. The heating performance of air-source heat pumps is rated by the Heating Season Performance Factor (HSPF), a ratio of the estimated seasonal heating output by the seasonal power consumption for the average U.S. climate. The HSPF of the more efficient pumps ranges from 7.7 to 10. The Energy Information Center recommends an HSPF of 8.5 or higher. The cooling performance of air-source heat pumps is rated with a Seasonal Energy Efficiency Rating (SEER), with the more efficient systems having a SEER of 13 or higher.

- A ground-source heat pump appears to be the most practical heat pump for the Minnesota climate. The heating efficiency of ground- or water-source heat pumps is rated by their COP, and their cooling efficiency by their Energy Efficiency Ratio, or EER. The most efficient of these pumps has a COP of 3.4 or higher and an EER of 16 or higher.

Cooling. Just as heating costs are reduced in an energy efficient home, so, too, are cooling costs. Higher insulation levels and increased air tightness of an energy efficient home keep the house cooler in summer as well as warmer in winter. If you decide to cool your house with air conditioning, you can either have a central system to cool the whole house or window or wall units that cool one or more rooms. Split units or high velocity units also are available for homes with hot water or electric heating, but these systems are also more expensive than the standard forced air unit which can use the furnace ductwork. For maximum efficiency, the air conditioner capacity should match the cooling load (it is important not to oversize). On room or wall units, check the Energy Guide label for the energy efficiency ratio (EER): the higher the number the better. The Energy Information Center recommends a rating of 10 or higher. Central air conditioners are rated by Seasonal Energy Efficiency Ratio (SEER) and should be 12 or higher.

Water heating. It is extremely important that a combustion water heater be direct vent (also called sealed combustion) or be the power draft type which exhausts its gases through the side of the house with a fan. Another option is to use a non-combustion water tank that is heated by a boiler.

Selecting an efficient heater is important. Check the yellow and black Energy Guide tag found on all new water heaters. The tag gives the estimated yearly cost of operating the unit and shows how the particular model compares in energy use to similar models. Another important piece of information is how much hot water the tank can provide. The ability of a water heater to meet peak demand for hot water is indicated by its "first hour rating."

Other measures to increase efficiency of the water heater include wrapping insulation around the pipes coming from the heater and wrapping the heater itself in an insulation jacket. The water heater also should be equipped with heat traps to cut down heat losses. Low-flow showerheads and faucet aerators that conserve hot water also reduce energy use for water heating.

An attractive new option for energy efficient homes is to combine water and space heating into a single unit. A number of these systems are on the market. Some appear no different than either a conventional water heater or furnace. Considerable savings in overall equipment costs and overall operating costs are likely.

Managed mechanical ventilation

Healthy indoor air requires a regular admixture of fresh outdoor air. In a cold climate like Minnesota's, this outdoor air cannot reasonably be provided year round by opening windows. A controlled, mechanical ventilation system is required. (Beginning April 15, 2000, a controlled mechanical ventilation system will be required by the state energy code.)

Developments over the past three decades in new home construction, materials, methods, and home furnishings make it even more important to manage indoor air quality with mechanical ventilation. Tighter construction and the prevalence of powerful exhaust equipment such as kitchen range fans and clothes dryers profoundly influence the indoor environment. It is important to remember that the entire home is a system that includes building structure and mechanical systems, and that these interact with each other. The structure and systems are also affected by the number of occupants, their life style, the size of the house, the outdoor climate, and the house site.

How much outdoor air is needed is based mainly on three factors: the volume of the home, the number of people in the home and their activities, and the amount of air exhausted out of the house by fans and other equipment.

Makeup air is the term for air that replaces air exhausted out by fans and other equipment. The amount of makeup air required varies according to the number and power (cubic-feet-per-minute, or cfm) of exhaust equipment and also on whether the furnace and other combustion appli-

Design Details: Overhangs and Split Levels

Two house designs that require special attention to achieve energy efficiency are floor overhangs, or cantilevers, and split levels. These designs create difficulty in maintaining a continuous air barrier. In the case of overhangs, the recommended practice is to fit rigid foam insulation panels between each floor joist cavity and seal at the edges with caulk. For the split level house, a number of special techniques have been devised. Talk with your builder about possible methods to use.

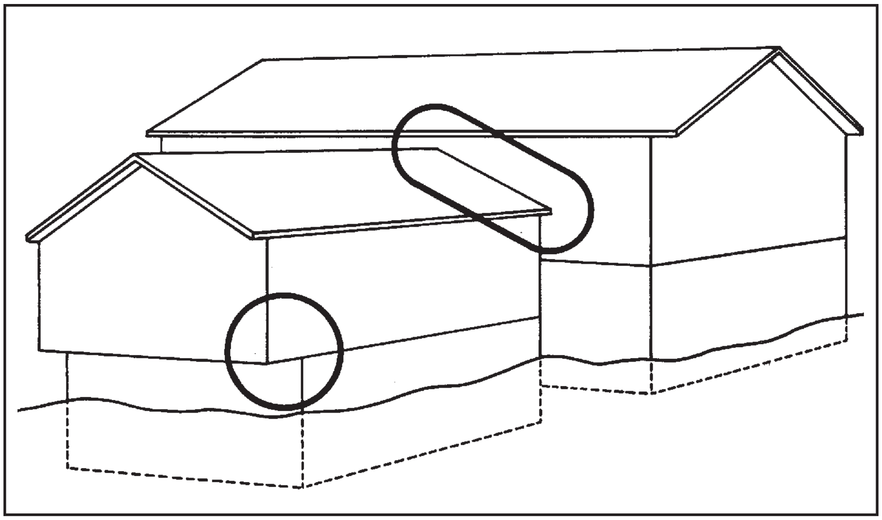


Figure 4

ances in the home are sealed combustion or power vented. In an energy efficient home, which has sealed combustion or power vented type furnace and water heater, the need for makeup air in some cases can be satisfied by passive intake – that is, air which enters without the aid of fans or other mechanical equipment. The Energy Information Center recommends, however, and the new Minnesota energy code in most cases will require, that powered makeup air (air brought in by mechanical means) be provided for clothes dryers with exhaust exceeding 160 cfm, kitchen exhaust fans over 250 cfm, and other exhaust equipment exceeding 100 cfm.

People ventilation. The Energy Information Center recommends, and the Energy Code will require, a base, 24-hour mechanical ventilation capacity of 15 cfm per person, plus 15 cfm for the house, with a minimum rate of 45 cfm. Depending on the volume of the house and the activities of the people inside, supplemental ventilation is required.

Different types of mechanical ventilation systems can provide the necessary outdoor air, as long as the system has the capacity to provide 0.35 air changes per hour to the house, distributed to all habitable rooms. Ask your builder what options you have for ventilating your home.

Whatever system is selected, it is important that the home owner understand the ventilation requirements and operate the system so as to provide the needed amount of fresh air. Although ventilation systems can use the same duct system as the furnace, it is strongly advised that the exhaust air have separate ductwork. If both intake and exhaust use the furnace system, the exhaust air can end up being recirculated rather than replaced with outside air.

During the first months after a home is constructed, the ventilation system should be operated continuously at the highest rate of operation possible to ventilate the extra moisture and gasses emitted from construction materials, carpets, and other new furnishings. After the first year, the ventilation system should be operated whenever the home is occupied. (The only possible exception being those beautiful days when all the windows are opened.)

Below are brief descriptions of some of the ventilation systems available.

- Central heat recovery ventilator (air-to-air heat exchanger). Currently, this is probably the most complete, readily available, and efficient ventilation system available. It consists of an intake fan, exhaust fan, and a duct system. It also has a heat recovery system that reduces indoor heating and cooling loads. This system can be run continuously, or it can be controlled by timers or a dehumidistat. Its major disadvantage is high initial cost.
- 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 controlled by a timer or dehumidistat. The initial cost is significantly less than that of a heat 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 in the kitchen and bathroom 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, bath, and other selected areas. In all of these cases, air is brought in, with fans or other mechanical equipment, through inlet vents and mixed with household air to warm it and then distributed through the home. All of these systems can be controlled automatically.

Installation recommendations. For all ventilation systems, it is always a good idea to locate exhaust grilles high on walls and run the ducts down the wall and the output from the fan 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. Minnesota's energy code will require that the ventilation system components be installed to minimize noise and vibration transmission, and also will require written certification that all components of the system are functioning in the manner intended.

Design Details: Tuckunder and Attached Garages

Because of the noxious fumes prevalent in garages, tuckunder and attached garages are required to be completely sealed from the rest of the house. A number of locations are vulnerable, however, to gaps in the air barrier separating the house and garage: the rim joist where the home's floor joists meet the frame of the garage/house wall; door and door frames from the garage into the house; and electric outlets or switches in the garage/house wall. A particularly difficult area occurs in a tuckunder garage where the common wall between the garage and home meets the living area floor/garage ceiling (see illustration below). One solution is to place rigid foam insulation panels vertically between the floor joists, sealing the edge with caulk. Additional problems can be created when pipes and ductwork are installed in the garage ceiling: these openings must be sealed to prevent air leaks, and insulation should be installed around the ductwork and pipes.

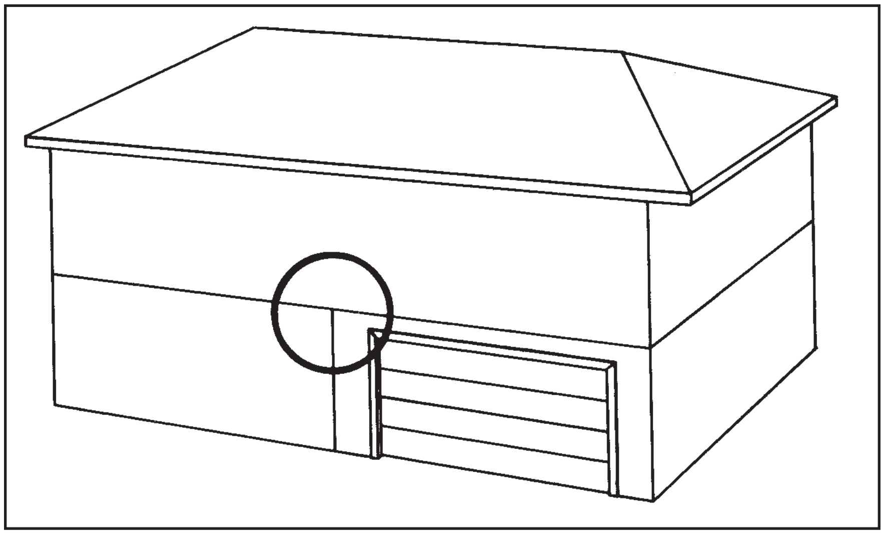


Figure 5

Design Details: Cathedral Ceilings

Builders can use a number of techniques to allow for added insulation in cathedral ceilings. The Energy Information Center recommends two options: the "scissors truss" or supplementing insulated rafters with rigid insulation. The scissors truss allows plenty of room for insulation and ventilation in the space separating the roof and ceiling. If the design does not allow for a scissors truss, roof rafters or truss can be fitted with R-38 batt insulation and an inch of rigid insulation added on the underside of the rafter or truss. Regardless of the method used, the two important features are maintaining a clearance of one or two inches under the roof deck for required ventilation and maintaining a tight air barrier to prevent warm, moist air flow from the living space.

Efficient and safe appliances and lighting

Home appliances and lighting are much more efficient than those of 15 years ago, and efficiency pays. Owning and operating a new appliance or lighting is like buying on the installment plan: the purchase price is only a down payment. The rest of the cost is paid through gas and electric bills, month after month, for as long as the appliance and lighting are used. These monthly energy costs add up. For example, running a refrigerator for 15 to 20 years typically costs three times as much as the purchase price. In the case of lighting, an efficient compact fluorescent lamp may cost more than a standard incandescent bulb, but it pays for itself several times over in energy savings and length of life.

When selecting appliances and lighting, look for the efficiency labels. Energy guide labels list the estimated annual operating cost of the appliance and how the particular model compares in energy use to other similar models. These labels are found on refrigerators, freezers, clothes and dish washers, ranges, and ovens. Efficiency labels also are required on the packaging of general service incandescent bulbs (30 watts or higher), compact fluorescent lamps designed to replace general service incandescent lights, and general service fluorescent lamps. The new labels list the light output (in lumens), the amount of energy used (in watts), and the life of the lamp (in hours).

In addition to checking the efficiency label for an appliance, be aware that other features can increase or decrease energy use. Chest freezers, for example, are typically 15 to 20 percent more efficient than upright freezers because they are better insulated and cold air doesn't spill out when they are opened. Clothes washers with a horizontal axis use much less water than standard top-loading machines, reducing energy use by as much as two-thirds. The Home Energy Guide on Appliances is a good source of information, as well as the publication Most Efficient Appliances (see bibliography).

Low toxicity materials, furnishings

The new home built to the standards described in this guide assures, to a considerable extent, a healthy indoor environment. Installing and operating a mechanical ventilation system and selecting sealed combustion or power vented combustion appliances greatly reduce the threat of carbon monoxide (CO) buildup. Mechanical ventilation combined with other measures to control moisture (i.e. a continuous vapor retarder and air barrier and foundation water proofing and other measures to control ground moisture and gases) reduces the source of mold growth and helps prevent radon entry.

Other indoor pollutants, however, particularly volatile organic compounds (VOCs) such as formaldehyde, can come into the home on products and furnishings. VOCs are chemicals that become a gas at room temperature. They are found in such products as particle board, plywood, paneling, pressed-wood products, and urea formaldehyde foam insulation. Some carpeting, synthetic fabrics, paints, solvents, pesticides, cleaners and disinfectants, air fresheners, and dry cleaned clothing contain VOCs. These sources of VOCs may be too potent to be diluted and dispersed by the ventilation system. The best prevention is to avoid bringing these materials into the home. The new home buyer, therefore, should work closely with the builder to select materials free of these pollutants.

More information on VOCs, radon, and other home pollutants are available from the Minnesota Department of Health, 651-215-0909. Another good source of information is the American Lung Association of Minnesota, 651-227-8014 or 800-642-LUNG.

Costs, Other Considerations

What will it cost?

Estimating the additional costs of incorporating the above components into the new home is difficult. Higher quality probably translates into higher costs, but a builder experienced in energy efficient construction may be able to build your home for a lower cost than a less experienced builder could. Explore other options for reducing the costs; for example, ask your local utility if it offers rebates on more efficient appliances, and ask your lender about energy efficient home mortgages. Remember also that a durable, quality home should have a higher resale value and its maintenance costs should be lower.

Home grounds

Although this guide has focused on home construction, the home site and landscaping also affect home energy use. If your home site offers you the opportunity, you could benefit from solar heating by placing more windows on the south side of the home and fewer on the north. Landscaping with trees and shrubs not only makes your home more beautiful, it can reduce home energy use. The principal points to remember are to shade west- and east-facing windows by planting deciduous trees, avoid planting trees south of windows, and create windbreaks by planting dense evergreens to the north and west of the home. A brochure on landscaping for energy saving is available from the Energy Information Center.

Selecting a builder; questions to ask

Throughout this guide the new home buyer has been advised to ask a number of specific questions regarding the components of an energy efficient home. All of these questions are good to discuss and you may, depending on the response of the builder, decide to select another builder. Below are suggestions for other questions to ask and factors to consider before selecting a particular builder.

- Ask how long the builder and company have been in service, will they provide references, what after-sale services do they offer, and do they provide a guaranteed third-party warranty and what specifically does it cover? (Third-party refers to those outside the company that the builder hires to perform specific jobs.)
- Ask for a description of the features included in the base price, along with a description and cost of options.
- Contracts you sign should clearly spell out what the builder is providing as standard inclusions and what you are paying for as upgrades.
- What kind of quality control does the builder provide for work done?
- Balance price and value. The range of prices in new homes generally reflects differences in location, features, and quality of construction. If a builder's prices seem out-of-line, ask for an explanation. Higher prices should reflect better quality materials, finishing, features, and service.

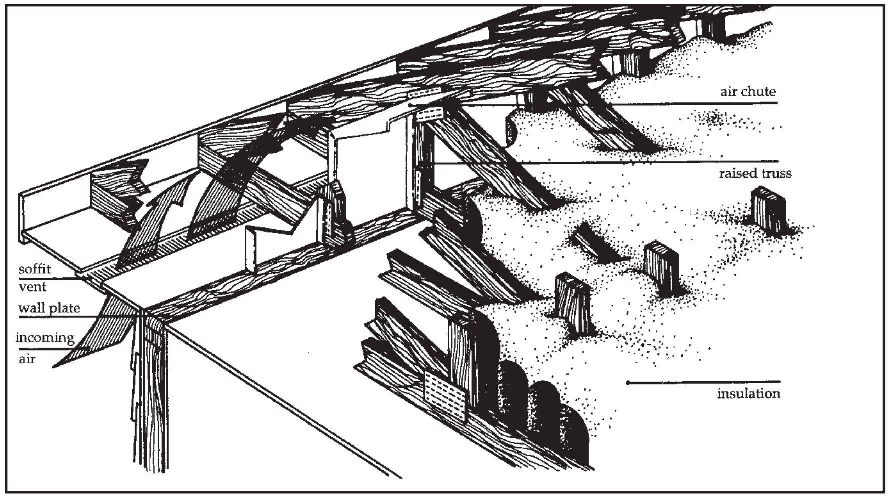


Figure 6
Raised trusses provide room for added insulation to extend to the edge of the attic, covering the wallplate. Air chutes (or baffles) protect insulation from incoming air from soffit vents.

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HOME ENERGY GUIDE

TECHNIQUES TACTICS & TIPS

House Diagnostic Services

Minnesota Department of Commerce Energy Information Center

Does your home have moisture problems, ice dams, window condensation, or poor ventilation? Are you concerned about carbon monoxide and other indoor pollutants? Are your utility bills too high? If so, you may need house diagnostic service performed by a professional building performance specialist. These specialists, sometimes referred to as "house doctors," have the diagnostic tools and the expertise to find the underlying cause of your home's problems and understand the "house as a system."

Having your house 'diagnosed' by a building performance specialist will tell you critical facts about your house – facts you should know before you invest in any major home improvement projects.

This guide explains what house diagnostics entails and will help you decide if and when your house needs diagnostic service. By providing a simple explanation of the various diagnostic tests available to you as a homeowner or builder, you will be prepared to shop for the specific services you need, whether it be one specific test for one specific problem or a comprehensive, whole house diagnostic package.

Following is a list of the primary diagnostic tests and services available to homeowners. Not all service providers perform all the tests, so make sure you find a specialist with the tools and expertise needed to properly address your home's problems.

For the building envelope:

- Visual inspection for attic, wall, window, roof, foundation and crawlspace problems
- Infrared inspection of attic, wall, and foundation insulation
- Moisture test of building materials
- Air pressure diagnostics for air leakage (blower door test)

For fuel combustion appliances:

- Carbon monoxide testing
- Draft pressure and spillage tests
- Combustion efficiency test
- Heat exchanger leak test
- Inspection and testing of ductwork leakage
- Combustion air requirements
- Make-up air requirements

For indoor air quality:

- Measuring carbon dioxide levels
- Measuring humidity levels
- Carbon monoxide testing
- Identifying mold sources
- Evaluating mechanical ventilation

Related Guides:
Combustion Air
Indoor Ventilation
Home Insulation
Caulking & Weatherstripping
Basement Insulation
Attic Bypasses
Windows & Doors
Home Moisture
New Homes

What diagnostic testing will tell you

Having your house 'diagnosed' by a building performance specialist provides critical information about your house before you invest in any major improvements.

- Is there enough fresh air coming in for your health and comfort and for your fuel burning appliances to operate safely?
- Could your house be too 'tight'?
- What is the carbon monoxide level in your home? (long term and short term levels)
- Are the furnace, boiler, and water heater properly venting to the outside? Are they operating as efficiently as they should be?
- Is the air inside your home too dry?
- Where are the inside air leaks and attic bypasses that are causing ice dams on the roof?
- Are there gaps in your wall or attic insulation?

When does a house need diagnostic services?

Most any home, new or old, benefits from house diagnostic testing. However, there are occasions when having a professional diagnosis can make the difference between spending or saving a lot of time and money to get the results you want. For example, if you experienced damage from ice dams, a new roof may not be the solution. Rather, you need to identify and correct the cause of the ice dams, which may be attic bypasses or a complex roof design . Diagnostic testing is most important in the following situations:

- **Homeowners who are planning a remodeling project or investing in any major home repair projects** should consider home diagnostic services a worthwhile investment before they begin the project and after completion.
- **When replacing appliances such as a furnace or boiler or a water heater, installing new windows or doors or adding new siding to a home,** the air leakage rate is changed. Any improvements made to a home that reduces air flow in a house may result in insufficient natural ventilation to remove moisture and other home pollutants and may reduce the amount of combustion air available for fuel burning appliance to operate safely.
- **Kitchen remodeling** where a new range and exhaust fan are added.
- **Prior to investing in mechanical ventilation** a blower door test can help determine the tightness of a house as well as the need for and type of controlled ventilation.
- **If mold and mildew are a problem,** diagnostic testing may be used to identify the moisture source causing the mold. Keep in mind, however, that most home performance specialists are not mold experts and that diagnostic testing does not always identify types of mold.
- **Any home with unexplained or chronic moisture problems** needs house diagnostic services to discover the sources of moisture. This will not only save money and time wasted on unsuccessful trial and error attempts at remedies, but can save the house itself from structural damage.
- **Anyone considering building a new home** may want to include diagnostic testing in their plans. A house diagnostician can identify potential problems and make improvements during the planning stage. Performing a blower door test before the sheetrock is in place will identify points of air leakage where potential moisture problems could develop. After the sheetrock and all appliances are installed, the house should be tested again for possible backdrafting problems.

Common diagnostic tests

Blower door test

A blower door test is a primary air pressure diagnostic tool that uses controlled pressure to locate the air leaks and determine the overall tightness of the house. The blower door equipment measures the structural air leakage by using a calibrated fan which creates an artificial pressure difference between the interior and exterior of the house. This test helps the specialist assess if there is sufficient natural ventilation to provide fresh air for the occupants of the house and adequate combustion and make-up air for appliances, such as the furnace or boiler, the water heater or gas stove. Identifying 'tightness' is an important element in understanding many problems, including window condensation.

Series leakage test

A series leakage test, a blower door test, provides more specific information about building air leakage, such as how much attic bypass leakage is there? Are the knee walls leaky to the inside or to the outside? How leaky is the basement perimeter? Are there leaks between the attached garage and the house? How will sealing the garage affect the house? Series leakage tests are a critical component in measuring air leakage and then predicting the results of sealing bypasses. For example, this type of pressure diagnostics may be used to detect carbon monoxide coming from an attached garage.

Combustion Safety Test

Combustion appliances such as gas furnaces and boilers, gas water heaters, or gas fireplaces should be checked for backdrafting potential at the time of installation and again when any modifications are made to the home. This appliance safety test measures the draft pressure for most furnaces, boilers and water heaters, with the exception of sealed combustion and power vented equipment. The test is performed when all exhaust appliances such as a clothes dryer, and bathroom and kitchen exhaust fans are operating. A blower door may be used to simulate down draft conditions. If spillage and backdrafting occur, the diagnostician should recommend the appropriate course of action.

Infrared inspection test

An infrared camera inspection can identify air leakage paths, called bypasses, as well as air movement in a home. It may detect high moisture content of building materials, including wet insulation. The infrared scan detects surface temperatures and visualizes "heat energy" in wall cavities enabling the building performance specialist to identify problem areas such as gaps in insulation and bypasses.

Indoor air quality test

If the major pollutant sources in the house are eliminated, the combustion equipment is safe ,and ventilation is adequate, the house will usually have good indoor air quality. Diagnostic testing offers the homeowner an understanding of how their house is performing and which strategies to use for improving indoor air quality. Keep in mind that most house diagnosticians are not experts on mold. While they can identify its source, do not expect them to evaluate or classify the mold itself.

Moisture diagnostic test

Many factors may influence moisture levels in a house. If a home has window condensation, evidence of mold, moisture on walls or in the attic, a building performance specialist can perform a test to determine the indoor humidity levels. The specialist may use a moisture meter to determine the moisture level of the building materials or a relative humidity gauge, called a hygrometer, to determine the humidity level of the indoor air. Along with this information the homeowner is offered recommendations for managing indoor humidity. If installing exhaust fans is required to remove moisture from the home, then it is critical that a combustion safety test and draft pressure test is performed to ensure that combustion gases are not backdrafting into the house. Keep in mind that combustion gases may or may not include carbon monoxide.

What is the cost of diagnostic service?

Before you begin diagnostic testing, ask your local gas or electric utility if they offer home energy audits. Having an energy audit done first will provide you with valuable information that can limit the cost of, or preclude the need for, diagnostic testing. Some diagnostic testing may be included in utility audits.

The cost of diagnostic service varies with the degree of analysis and expertise, so it is advisable to shop around for a service provider as you would shop for other products and services. Be aware that many home performance specialists provide only a diagnosis and recommendations for treatment and do not do the repair work themselves. Others may offer to fix the problems and the homeowner may choose to contract with them. Most specialists will send information to you describing their services and a price list. The more specific you can be about the problems in your home, the more you will be able to get a reliable estimate from the diagnostician.

Where can I find a building performance specialist?

The Energy Information Center maintains a list of house diagnosticians. These building performance specialists understand your house as a 'system' – an important concept in today's building science. Contact the Energy Information Center for a current list of service providers.

HOME
ENERGY
GUIDE

TECHNIQUES TACTICS & TIPS

APPLIANCES

Minnesota Department of Commerce Energy Information Center

Home appliances are big energy savers – and big energy users. They eliminate much of the labor involved in such tasks as washing and drying clothes and cooling and cooking food. At the same time, they use significant amounts of electric and natural gas energy. Appliances and lighting account for about one-fifth of all the energy used in the home.

The good news is that appliances and lighting are becoming more energy efficient. Appliance models on the market today are much more efficient than those of ten or more years ago, and compact fluorescent lamps are available that use about 75 percent less energy and last about ten times longer than the incandescent bulbs they can replace.

The National Appliance Energy Conservation Act set minimum energy standards for many appliances and specified deadlines for meeting those standards. The law also directs the Secretary of Energy to review the standards and upgrade them when improvements in technology make it worthwhile. The standards apply to date of manufacture, not date of sale. Standards went into effect for the following appliances on January 1 of the specified year:

Dishwashers, clothes washers, clothes dryers, ranges, ovens – 1988;

Room air conditioners, pool heaters, water heaters – 1990;

Refrigerators, refrigerator/freezers, and freezers – 1993; and

Central air conditioners, central air conditioning heating pumps, furnaces and boilers, direct heating equipment – 1992.

Look for the efficiency labels

New appliance and lighting energy labels are another recent change. The new appliance labels are easier to read and more useful to consumers in comparing energy efficiencies of different models. In addition to listing the estimated annual operating cost of the appliance, they show how the particular model compares in energy use to other similar models. (See Figure 2.)

New labels are also required for three types of lamps: general service incandescent bulbs (30 watts or higher), compact fluorescent lamps designed to replace general service incandescent lamps, and general service fluorescent lamps. The new labels list the light output (in lumens), the amount of energy used (in watts), and the life of the lamp (in hours).

In the near future, "Energy Star" labels will begin appearing on appliances and other products used in buildings. Initially developed by the U.S. Environmental Protection Agency for computers and other office equipment, the "Energy Star" label will be greatly expanded to serve as a seal of approval on most energy efficient refrigerators, water heaters, air conditioners, thermostats, and building materials such as insulation. The plan is to rank competing products based on their energy efficiency and offer the label to those ranking in the top 25 percent.

Related Guides:
Low Cost/No Cost Ideas
Home Lighting

What is the true cost of an appliance?

Owning and operating a new appliance is like buying on the installment plan. The purchase price is only a down payment. The rest of the cost is paid to the utility company through gas and electric bills, month after month, for as long as the appliance works. These monthly energy costs add up. For example, running a refrigerator for 15 to 20 years typically costs three times as much as the purchase price.

When shopping for new appliances, look not only for a good purchase price, but for energy efficiency as well. Following are the annual energy use and approximate annual energy costs (based on a rate of 7 cents per kWh and $.50 per therm of natural gas) for the most efficient models of some appliances. These efficiencies are for recent models, but continuing improvements make it likely that new models coming on the market will have even higher levels of efficiencies.

- Refrigerator, 21 cubic foot capacity, with side mounted freezer and through-the-door ice maker, automatic defrost: 561 kWh, $39.
- Clothes washer, standard capacity, top loading: 267 kWh, $19.
- Water heater, natural gas, first-hour rating 40 gallons: 242 therms, $121.
- Freezer, 21.2 cubic feet capacity, upright type, manual defrost: 482 kWh, $34.
- Dishwasher, standard capacity: 471 kWh, $33.

Appliance operation and maintenance

Buying an efficient appliance is the first step in reducing appliance energy use and costs; equally important is the next step – maintaining and operating the appliance to ensure maximum efficiency. Read the owner's manual that comes with the appliance and carefully follow manufacturer's recommendations. If you have misplaced your owner's manual, contact the manufacturer and ask that a manual be sent for the specific model you own.

Buying used appliances

The Energy Information Center strongly recommends buying a new rather than a used appliance. Although used appliances are substantially cheaper than new appliances, they are generally less efficient than new models of similar style and size and therefore are actually more costly.

The money saved by reduced energy consumption is likely to justify the cost of purchasing a new appliance. This is especially true for appliances such as refrigerators, which in recent years have improved substantially in energy efficiency.

If forced to buy a used refrigerator, look for energy efficient features described in the sections below on individual appliances. Also, call the manufacturer and ask for the Energy Guide label for the model you are considering.

Repairs

When an appliance needs repair and it is covered by a warranty, be sure to use an authorized service dealer; otherwise you may not be reimbursed for the cost of the repair. If the warranty period has elapsed, but the problem began while the appliance was still under warranty, you may be able to be reimbursed. Be sure to check. Also, when having an appliance repaired, routinely have the service person check and replace worn gaskets and belts.

When you go on vacation

When you leave the house for a few days or longer, you can reduce appliance energy costs by taking a few simple steps. These include:

- Unplug TV sets and all other appliances that aren't too difficult to re-program. Also unplug the little transformers and charges for cordless vacuums and phones.
- If you will be gone for a long time, you can empty your refrigerator and set it on its warmest setting (but not turn it "off").
- Turn all incandescent lights off and place fluorescent lamps on a timer to help discourage break-ins.

Common Small Appliance Energy Use and Cost*

Appliance	Typical wattage	Typical hours used/month	Typical cost/ month
Coffee makers, automatic drip with			
low wattage	1550	9	$.98
warming	50	300	$1.05
Toaster oven	1436	6	$.60
Toaster	1146	3	$.24
Blender	386	3	$.08
TV, color, 19" or larger	200	210	$2.94
Stereo	109	83	$.63
Radio	71	101	$.50
Personal computer	25	120	$.21
VCR	25	10	$.02
Water bed heater	400	360	$10.08
Electric blanket***	117	200	$1.26
Hair dryer	1200	8	$.68
Vacuum cleaner	630	6	$.27
Clock	2	730	$.11
Fan, oscillating	88		less than $.0 1/hour
Fan, window	200		less than $.01/ hour
Humidifier	120		less than $.01/ hour

*** Full wattage is not on all the time.

* Based on a cost of $.07 per kilowatt-hour

The Fridge

Keeping the refrigerator clean and in good condition is a major factor in its efficient operation.

Refrigerators & Freezers

Refrigerators particularly have benefited from recent advancements in energy efficiency: the average refrigerator today is at least two to three times as efficient as the average model of 10 or more years ago.

Choosing a refrigerator and freezer

- Buy the appropriate size for your needs. Too large a refrigerator, besides costing more than a smaller model, wastes space and energy. Too small a model leads to extra trips to the store.
- A second refrigerator? Generally it is much less expensive to buy and operate one refrigerator than two smaller refrigerators.
- Chest freezers are typically 15-20 percent more efficient than upright freezers because they are better insulated and cold air doesn't spill out when they are opened.
- Manual defrost refrigerators use less electricity than automatic defrost models, but they are not widely available in large sizes. Manual defrost models also must be defrosted on a regular basis to maintain their efficiency.
- Manual defrost freezers are more common than automatic defrost models and generally do a better job of storing food. Since the freezer is opened less frequently than a refrigerator, frost builds up more slowly.
- Features such as automatic icemakers and through-the-door dispensers can increase energy consumption and frequency of repairs.

Installation

- Air must circulate freely around refrigerator/freezer condenser coils so they can give off heat. The unit also will fail to lose heat properly if it is located in direct sunlight or next to the dishwasher or stove/oven.
- Although refrigerators and freezers should be located in a somewhat cooler area, during the winter they should be in heated space – at least 60 degrees F. for best operation. Never locate an automatic defrost freezer in an unheated space.

Operation and maintenance

- Consult your owner's manual for specific instructions. Remember, keeping the refrigerator in good condition, and cleaning the food compartments as well as the refrigerator coils, are major factors in the efficient operation of a refrigerator.
- Temperature inside the refrigerator should be about 38 degrees F. or a little lower; the freezer compartment should be about 0 to 5 degrees F. Place thermometers in each compartment; if the temperature varies significantly from the thermostat settings, the refrigerator or freezer probably needs attention.
- On manual defrost models, do not allow more than a quarter-inch of ice build-up in the freezer or freezer compartment before defrosting.
- If you have a second refrigerator that is needed only a few days a year, turn it off when it's not in use. Be sure to chain the door shut or turn the door to the wall to make sure children can't climb in.
- Many automatic defrost refrigerators have small heaters built into the walls to prevent moisture from collecting on the walls when humidity is high. Some models have a switch that allows you to turn the heaters off; during periods of low humidity, when there is little frost build-up, turn the switch off to reduce energy use.
- Make sure refrigerator and freezer doors shut tightly. Test by closing the door or doors on a piece of paper and then trying to remove it. If the paper pulls out easily, heat is leaking into the appliance and new seals are needed. Since new seals are not cheap, this may be a good time to evaluate whether to buy a new refrigerator or freezer.

Cleaning

- Condenser coils are located in the back of older refrigerators and at the bottom of most new ones. They should be periodically cleaned with a vacuum or brush. Be sure to unplug the refrigerator when cleaning the coils. The coils on freezers also should be cleaned regularly.

Washers & Dryers

- Use the energy guide labels to help you buy the most efficient clothes washer. Energy use for a standard top loading washer, for example, ranges from 267 kWh per year for the most efficient model to 1818 kWh for the least efficient. This makes a difference of more than $100 a year in energy costs.
- Equally important, look for models with water level and water temperature controls. Since up to 90 percent of the energy needed to wash clothes is used to heat water, controls that allow you to use cooler water and adjust the amount of water to the load save energy. Remember, however, that one large load uses less energy than two small loads.
- Consider a front loading machine with a horizontal axis of motion; this kind of washer is more efficient and uses less water and detergent, significantly reducing monthly operating costs.

Washer operation

- Most laundry loads can be washed in cold or warm water, significantly reducing the amount of energy used. CAUTION: "cold water" as used in manufacturer's literature and by makers of detergents means 70 degrees F. In Minnesota, the temperature of the cold water going into the machine can be below 50 degrees F., which is too cold to clean clothes properly. You may have to use the warm water setting.
- Wash full loads.

Choosing an efficient dryer

- Energy guide labels are not required on clothes dryers. To buy the most efficient dryer, look for energy-efficient features such as an automatic temperature control, a moisture sensor control, a cool-down cycle, and a no-heat cycle. These features can be found on both gas and electric dryers. The dryer may have several selections based on type of fabrics being dried; regardless of the number of these options, dryers have either two or three heat settings.
- All new gas dryers sold in Minnesota after January 1, 1979, have electronic ignition. In 1983, most U.S. manufacturers made electronic ignition a standard feature for clothes dryers. Some propane clothes dryers may still have pilot lights. Since pilot lights increase annual gas consumption, you will save money by selecting a dryer with electronic ignition.
- Moisture sensors automatically turn the dryer off as soon as the clothes are dry and typically cut energy use by 10 to 15 percent. With a timer only, the dryer may run longer than necessary. Look for a dryer with an alarm announcing the end of the drying cycle and a post heat tumbling cycle to prevent wrinkling.

Dryer operation

- It is important to remember that the clothes dryer exhaust adds to the removal of air from the home and can be a factor in reducing the amount of combustion air available for furnaces and other fuel-burning appliances. If the dryer uses natural gas, it, too, will require combustion air. A shortage of combustion air can cause backdrafting of dangerous gases into the home, so it is important to ensure an adequate combustion air supply.
- The most important way to save energy and money with your clothes dryer is to shorten the drying time. Set the dryer moisture sensor and automatic temperature control to keep drying time to a minimum and to prevent over-drying. Over-drying not only wastes energy, it also shortens fabric life, causes wrinkles, and generates static.
- Two small loads will consume more energy than one large load; be careful not to overload the dryer, however, since this causes wrinkling and uneven drying.
- Clean the lint screen between each load. Lint restricts air movement, which can cause the dryer to run longer.
- Twice a year, disconnect the exhaust hose and clear of lint. Always use smooth metal ducting for the dryer exhaust. Flexible exhaust hoses increase operation time and trap lint, increasing fire risk. Tape all seams from dryer to exhaust.
- Check the dryer exhaust vent periodically to make sure it operates properly and doesn't leak. The flapper on the outside should open and close freely; if it remains open, it allows heated

The Laundry

Always vent the dryer outside to prevent moisture damage to the home and to keep contaminants out of the air.

Cooking

Check the size of the cook top or hood exhaust fan and make sure there is adequate make-up air.

air to escape from the house during the winter. Check the flapper once a month and remove lint buildup.

- Always vent all dryers outside to prevent moisture damage to the home and to keep laundry contaminants out of the air you breathe.

Dishwashers

Dishwashers, like clothes washers, use energy for heating water as well as to actually run the dishwasher. An efficient automatic dishwasher, when used properly, normally uses less hot water than washing dishes by hand. The savings in water heating often make up for the power consumed by the dishwasher

Choosing a dishwasher

- Dishwashers carry the yellow and black energy guide label which compares energy use of the particular model with energy use of similar models. Check this label to ensure that you are buying a more efficient model, one that will save money on your energy bills. Efficiency of new models has improved 20 percent during the past two years.
- The majority of the dishwasher's energy use goes to heat water and not to run the machine, so it pays to look for features that reduce hot water use.
- Dishwashers do not need water heated to 140 degrees F. to dissolve detergent and cut grease. A setting of 120 degrees F. is the highest temperature needed for household use. This setting reduces water heating costs six to ten percent, compared to a 140 degree setting.
- Other useful features are short cycle and air-dry selectors. Short cycles use less hot water and are suitable when dishes are only slightly soiled. An air-dry selector automatically shuts off the heat during the drying cycle, cutting electricity use by up to 20 percent.

Installation

- The Department recommends that you do not locate your dishwasher next to a refrigerator or freezer. Dishwashers produce moisture and heat which cause the refrigerator and freezer to use more energy.

Operation

- Wash only full loads. Running two half loads can take twice as much energy as a full load.
- Don't waste water or your time by pre-rinsing dishes. Most newer model dishwashers require only that food be scraped off and liquids emptied. If you do pre-rinse, use cold water. Use short cycles when you have easy-to-clean loads.

Cook Tops & Ovens

The kitchen range consists of a cook top and an oven. Because many modern kitchens have separate cook tops and ovens, this guide refers to the combination as a "range." It also uses the term "gas" for both natural gas and propane.

Choosing a new range, cook top, or oven

- Electronic ignition replaces the pilot light on a gas range and cuts gas use by about 40 percent. All new natural gas ranges are now required to have electronic ignition. Propane ranges also are available with electronic ignition.

Electric cook tops

The most common electric burners in America are exposed coils, but a variety of new styles are available.

- Radiant elements under ceramic glass are easier to clean than exposed coil cook tops, but they are slower to heat up. It is important to use flat pans with this type of surface.
- Electric induction cook tops use magnetism to heat the pan. They may be a separate cook top or part of a range. They cut electric consumption substantially – by as much as half – and control temperature more easily than conventional electric cook tops do. They also are safer because they are cooler and less likely to cause burns, and their flat surface makes them easier to clean. Induction cook tops have some disadvantages, however. They can only be used with steel and iron pans, and they are more expensive than regular cook tops. Their extra expense may not be justified by their energy savings.

- Halogen cook tops use halogen lamps to heat a smooth glass surface. They provide heat quickly and are more efficient than regular cook tops, but they also are more expensive.

Ovens

- Convection ovens circulate hot air with a fan, providing for more even temperature in the oven. Because of this even heat, temperatures often can be lowered and cooking times shortened, thereby reducing energy use. The more even temperatures also allow for more items to be cooked at the same time.
- Self-cleaning ovens are up to 20 percent more energy efficient because they have more insulation. If you use the self-cleaning function more than once a month, however, you'll use more energy than the insulation saves.
- Microwave ovens use up to two-thirds less electricity than conventional ovens, but they require special cooking utensils and are not suitable for cooking all types of food. They are not a substitute for an oven for major meal preparation. Some microwave ovens have features that save additional energy, such as variable power settings and controls to turn off the oven when the food is cooked.

Ventilation equipment

- AN IMPORTANT CAUTION. Check the size of the exhaust fan and make sure that there is adequate make-up air. 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 is serious; if the negative pressure is strong enough, it can cause the furnace and other fuel-burning appliances to backdraft dangerous gases into the home. All exhaust fans, including clothes dryers, must have an adequate supply of make-up air. For information on make-up air, call the Energy Information Center.
- Ventilation is necessary to remove cooking fumes, grease, moisture, and smoke. Hood or cook top exhaust fans should vent directly to the outside .
- If the range, oven, or cook top is on an inside wall and can't be directly vented to the outside, a remote exhaust vent with a damper located on the kitchen wall is the next best option. This system can work with other household exhaust fans and fresh air intakes to improve indoor air quality. To discuss further options for ventilation, call the Energy Information Center.
- Recirculating ventilation hoods are partially effective for removing certain cooking pollutants, but ineffective for removing moisture or gases.

Efficient operation of cook tops and ovens

- Cook tops and ovens are generally not very efficient at cooking small quantities of food. Microwave ovens, toaster ovens, pressure cookers, and the common insulated ceramic pot with an electric heating element use less energy than cook tops or ovens.
- On gas ranges, keep the flame away from the bottom of the pot.
- On electric ranges, use pots and pans with flat bottoms. They provide the best contact with electric cook tops. Also, the element can be turned off a few minutes ahead of time and the hot element will continue to cook the food.
- Keep oven preheating to a minimum. Preheating is often unnecessary. Keep the oven door closed except when the food must be treated or moved. Up to 50 percent of the heat escapes each time the oven door opens. Food takes longer to cook and the loss of heat can affect browning and baking results. Use timers instead.
- Don't cover oven racks with foil; this reduces heat flow and increases cooking time. Also, don't line the bottom of the oven with foil, since the foil blocks secondary air supply to the burners and leads to increased carbon monoxide production.
- For efficient microwaving, keep inside surface clean so that microwaves can reach food effectively. Defrosting food in a microwave may be convenient, but defrosting at room temperature is free.

Compact Fluorescent Lamp

Light Output:
1200 lumens

Energy Used:
20 Watts

Life:
10,000 hours

Incandescent Lamp

Light Output:
1710 lumens

Energy Used:
100 Watts

Life:
750 hours

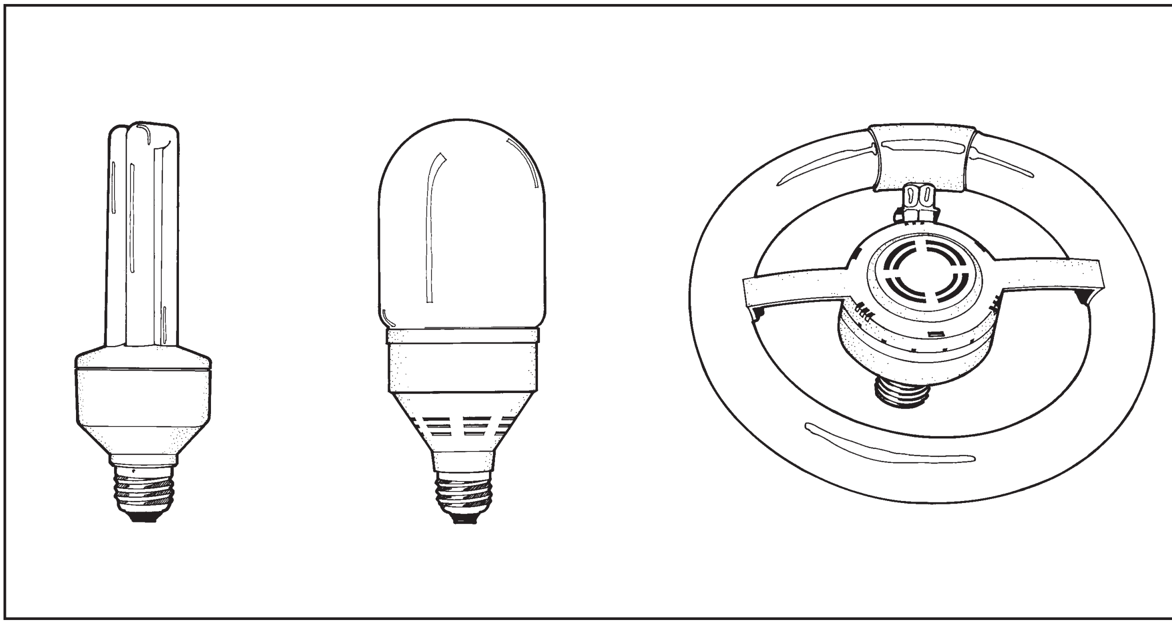


Figure 1
Compact fluorescents come in a variety of shapes and sizes to fit different fixtures.

Lighting

Lighting accounts for five to ten percent of total home electric use. The incandescent bulb has long been the standard home lighting fixture; however, recent advances in technology make it possible to replace incandescents with high quality light that uses much less electricity than incandescents.

Selecting efficient lighting

- Compact fluorescent lamps come in a variety of shapes and sizes and can replace incandescents in many table and floor lamps and in ceiling and wall fixtures as well. These lamps provide the amount and quality of light comparable to incandescent bulbs while using much less electricity. A 15-watt compact fluorescent lamp, for example, provides about the same amount of light as a 60-watt incandescent bulb. Check the energy label and compare light output and watts used with that of incandescent bulbs. (See Sidebar.)

  Compact fluorescent lamps also save money. Although their initial cost is significantly higher ($15 to $20, compared to $.75), their long life (more than 10 times that of an incandescent) and energy savings make them half as costly as incandescent lighting.

  You'll get the most benefit from compact fluorescent lamps by using them in fixtures that are used for three or more hours a day. One caution: fluorescent lamps cannot be used with dimmer switches. For outdoor use, choose a compact fluorescent rated to -20 degrees F.

- Color quality. The quality of tube fluorescents has greatly improved; special phosphors produce a high quality light in warm and cool tones. Color Rendition Index (CRI) is a measure of the ability of the light to illuminate colors accurately. Look for lamps with a CRI rating of 85.

- Tungsten-halogen incandescent bulbs are a good choice where fluorescent lighting cannot be used – with dimmers, for example. Tungsten-halogen are more efficient (10 percent or more) than regular incandescents and last up to three times as long. They bring out the true colors of what they illuminate, and are available in floodlight, spotlight, and general service models. Tungsten-halogen PAR (parabolic aluminized reflector) lamps are appropriate for recessed lighting or track lighting and are 40 percent more efficient than incandescent reflector lamps.

Lighting label requirements

Federal law requires that specific information on energy efficiency be included on the packaging for these lamps: general service incandescent, compact fluorescent, and incandescent reflector. Their light output, energy used, and life ratings must be listed in terms of lumens, watts, and hours, respectively. The label for a general service fluorescent lamp must contain the capital letter E, printed within a circle, with the statement that this symbol means the bulb meets federal minimum efficiency standards.

Lighting controls

Automatic lighting controls also save energy. They include:

- Electronic dimmers regulate the brightness of incandescent and tungsten halogen lights, allowing you to alter lighting levels according to need and also save energy.
- Motion sensing light switches turn lights on and off automatically when someone enters a room, reducing the waste of energy that results when people forget to turn off the lights.
- Electronic timers turn lights on and off at specific times, and are often used for home security.

Using lights efficiently

- Use task lighting, rather than general space lighting, when appropriate. For example: a cabinet light to illuminate kitchen work surfaces, a reading lamp next to a chair, and a light over a sewing machine.
- Use natural daylight as much as possible. In rooms where you read or for other reasons need bright light, use light colored furnishings, light wall and ceiling surfaces, and reflective louvers or blinds to bring as much daylight as possible inside.
- Clean your light fixtures; accumulated dust can significantly reduce a bulb's output.
- Use airtight, recessed ceiling fixtures that reduce air leaks and are rated for insulation contact. Airtight fixtures help keep warm moist air from leaking into the attic and condensing onto insulation, adversely affecting its insulating ability.
- A fixture with a single bulb gives more useful light than one with several bulbs having the same total wattage. For example, four 25-watt bulbs give only half the light of one 100-watt bulb.
- Outdoors, in the garden or along pathways, use low-voltage incandescent or tungsten-halogen lamps. High pressure sodium lamps are a good choice for security lighting on garages and other buildings. Lighting controls are also useful outdoors; these include automatic timers, photocell controls that automatically turn lights on at dusk and off at dawn, and security spot lights that turn on and off when someone steps in and out of their range

Computers & Office Equipment

More and more people are using computers and other office equipment at home. In fact, for many Americans, home is also their place of work. In 1993, more than a third of households owned computers.

Casual use of a personal computer at home does not use large amounts of electricity; however, large computer monitors, laser printers, and home copy machines used in a true home office workday can be significant energy consumers.

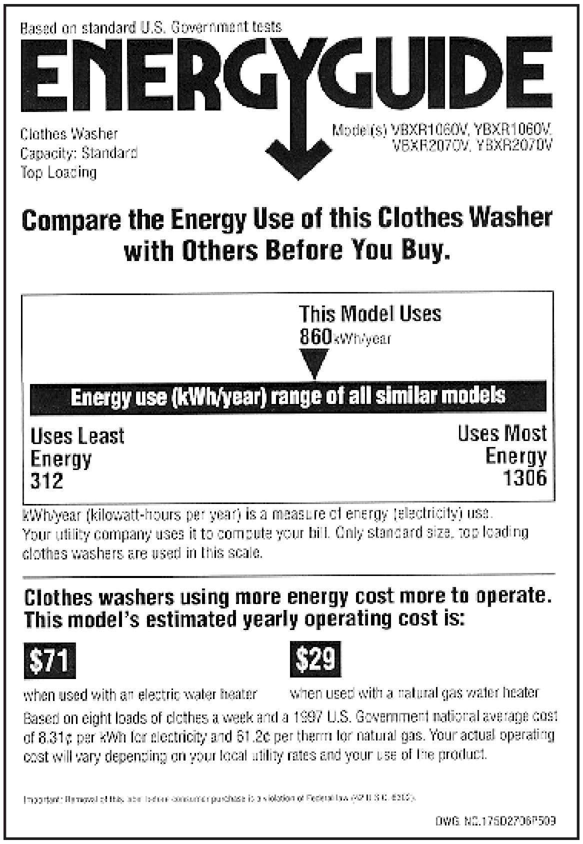
Selecting efficient equipment

- Look for and buy computers, monitors, and printers with the U.S. Environmental Protection Agency's Energy Star label.
- Computers, monitors, and printers that feature an automatic standby – or "sleep" – mode save energy when they are not in use. The Energy Star label is awarded to equipment that has this feature. It is important to remember, however, that the Energy Star label does not indicate the amount of energy the equipment uses when it is in use, and this varies considerably.
- Although desktop computers are clearly the choice of most people, lap top computers are much more efficient, costing around $5 a year to operate nine hours a day for 280 days.
- Faster computers tend to use more energy than slower models. Color monitors use twice as much electricity as black and white, with one exception: LCD (liquid crystal display) color

Look for the Energy Labels

At right is a sample of the Energy Guide label for appliances. The Federal Trade Commission (FTC) requires that this type of label appear on refrigerators, refrigerator/freezers, freezers, dishwashers, clothes washers, and water heaters.

See Compact Fluorscent Lamp Sidebar. The FTC requires this information on compact and other general service fluorescent and incandescent lamps. To buy the most efficient lamp, find lamps with the light output you need and compare watts. Those with the lowest wattage save energy. The life of the lamp also helps determine its value. A compact fluorescent, for example, may cost more than an incandescent, but it pays for itself several times over in energy savings and length of life.


Based on standard U.S. Government tests

ENERGYGUIDE

Clothes Washer
Capacity: Standard
Top Loading

Model(s) VBXR1060V, YBXR1060V, VBXR2070V, YBXR2070V

Compare the Energy Use of this Clothes Washer with Others Before You Buy.

This Model Uses
860 kWh/year

Energy use (kWh/year) range of all similar models

Uses Least Energy	Uses Most Energy
312	1306

kWh/year (kilowatt-hours per year) is a measure of energy (electricity) use. Your utility company uses it to compute your bill. Only standard size, top loading clothes washers are used in this scale.

Clothes washers using more energy cost more to operate. This model's estimated yearly operating cost is:

$71	$29
when used with an electric water heater	when used with a natural gas water heater

Based on eight loads of clothes a week and a 1997 U.S. Government national average cost of 8.31¢ per kWh for electricity and 61.2¢ per therm for natural gas. Your actual operating cost will vary depending on your local utility rates and your use of the product.

DWG NO.175D2706P509

Figure 2

monitors are generally more efficient than standard models.

- Laser printers are less energy efficient than inkjet and dotmatrix printers. Although laser printers are of higher quality, in many cases the quality of the less efficient printers is sufficient for home use.
- Liquid ink photocopiers use slightly less energy than other types, but the copy quality is not quite as good. Inkjet copiers use quite a bit less energy than others, but they are slower. Digital duplicators are more efficient for high volume applications.
- Photocopiers with standby or sleep modes reduce energy use when inactive. Higher-volume copiers use more energy per copy.
- Phone faxes are efficient since they add only slightly to the amount of electricity consumed by telephone answering machines. Inkjet faxes typically use less energy than other types; thermal fax machines are the next best in terms of efficiency, and laser faxes use the most power.
- A fax modem installed in your computer saves energy since you won't have to print out the messages.
- Integrated systems that combine printing, scanning, faxing, and copying generally are more energy efficient than having separate units.

Operating equipment efficiently

- Turning off your computer monitor whenever it won't be used for 15 minutes or more and turning off the computer when it won't be used for two hours or more, saves energy and is not harmful to the equipment.
- Doing your printing at one time, and leaving the equipment off for the rest of the day, reduces energy use. The same principle applies to photocopying.
- Using less paper saves more energy than using more efficient equipment does. Eliminating wasteful spacing; printing only final copies, not drafts; and printing or copying on both sides of the paper are ways to reduce energy use.

Bibliography

American Council for an Energy-Efficient Economy (ACEEE), *Consumer Guide to Home Energy Savings.* Contact ACEEE, phone 510-549-9914.

Minnesota Department of Commerce Home Energy guides: *Home Lighting* and *Combustion Air.* Single copies available free by calling the Energy Information Center, 612-296-5175 in the Twin Cities; 1-800-657-3710 from elsewhere in Minnesota, or http://www.dpsv.state.mn.us (Internet).

Northern States Power Company, *EnergyWise Guide to Home Energy Conservation.* For availability of copies, call NSP, 612-330-6000.

Rocky Mountain Institute, *Homemade Money: How to Save Energy and Dollars in Your Home.* Contact the Institute at 970-927-3851 (phone), 970-927-3420 (fax), or orders@rmi.org (e-mail).

HOME ENERGY GUIDE

TECHNIQUES TACTICS & TIPS

Home Lighting

Minnesota Department of Commerce Energy Information Center

It may seem hard to beat the familiar Edison light bulbs we've all used for years. They are inexpensive, fit our fixtures, are readily available and give off a pleasing light we are all comfortable with. However, the standard incandescent light bulb is terribly inefficient. Because almost all of the electricity going into it is lost in heat, the light bulb is actually much better at providing heat than light.

New lighting products are not only more energy efficient, they offer many more possibilities to improve the quality of lighting our homes, indoors and out.

This guide looks at some of the new technologies for residential lighting, identifies four basic strategies you can apply, then provides specific examples of how to put the new strategies into practice throughout your home – room by room.

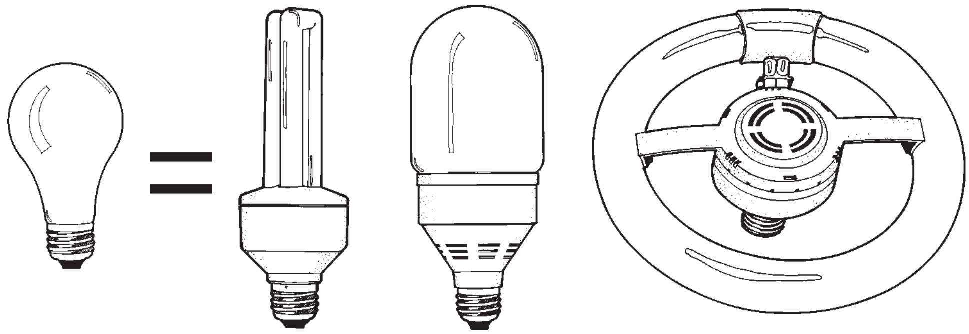
The new technology and how to use it: 4 strategies

Strategy 1: Replace standard incandescent lamps with compact fluorescent lamps.

No other new product in the lighting industry has had as great an impact as the compact fluorescent lamp (CFL). Modern CFLs have taken the best aspects of fluorescents – high efficiency and long life – while eliminating traditional problems of

Common replacements

Incandescent Watts (lumens)	Compact Fluorescent Watts (lumens)
60 (900)	16 (900)
75 (1200)	20 (1100-1200)
100 (1750)	30 (1600-1800



Compact fluorescents come in a variety of shapes and sizes to fit different fixtures.

Related Guides:

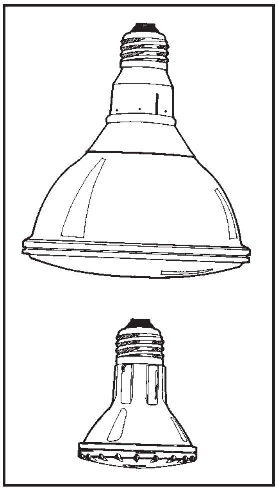
Low Cost/No Cost Ideas

ApOpliances

Tip:

Look for the new "improved color" fluorescent tubes.

If you can't use fluorescents, look for "halogen" bulbs.



Tungsten-halogen reflector lamps are 40% more energy efficient than incandescent R-lamps.

poor color, flicker and noise. Although, CFLs still cannot be used with dimmer switches and do not perform well outdoors in cold weather. They cost an average of $10 to $25 per bulb, but they last ten times longer than incandescents and use 60 to 75 percent less electricity!

You'll get the most benefit by switching to CFLs wherever you use high wattage incandescent lamps more than three hours per day – often in the kitchen and family room.

Strategy 2: Replace standard incandescent ceiling fixtures (especially in the kitchen and laundry area) with fluorescent fixtures equipped with tri-stimulus phosphor lamps.

These lamps provide the energy savings of fluorescent lighting with an improved color that compliments rather than clashes with natural daylight. Kitchen and laundry areas especially need and use lots of light, so look for big savings in these areas.

New fluorescent 4-foot tube lights coated with "tri-stimulus" phosphors come in three shades of white. The "warmest" of the three provides a light similar to incandescents and is designated 3000K. The lamp with the coolest hue has a rating of 4100K. There is also a lamp with an "in-between" color designation of 3500K. When offered the choice, most people prefer 3000K and 3500K lamps. Although these lamps cost about $8 to $12, with a rated life of 20,000 hours they can be expected to last over ten years in most residential applications.

Strategy 3: Replace incandescent spot and flood lights with "T-H" PAR lamps. Or better yet, manufactured compact fluorescent flood lamps. These new arrivals on the market in R-30 and R-40 sizes can easily replace many floods and spots used indoors.

In places where fluorescent lighting cannot be used, tungsten-halogen (T-H) lighting is a good choice. Basically a more efficient form of incandescent lighting, although not as efficient as fluorescent, "halogen" bulbs produce a crisp light that brings out the true colors of your furnishings – which makes this lamp popular with decorators.

In your recessed ceiling or track lighting fixtures, a good replacement is the T-H PAR (parabolic aluminized reflector) lamp, which is 40 percent more energy efficient than incandescent reflector lamps, costs about $7 and can be used indoor and outdoors.

You can also get T-H "A-line" (traditional style) b to replace standard 60, 75 and 100 watt incande cents. They use 12 percent less electricity and ha a longer life – at an average cost of $3 per bulb.

Strategy 4: Use automatic lighting controls i dining rooms, hallways – or anywhere!

A number of easy to install lighting controls a available that will increase your lighting flexib ty, your home security and your energy saving

- **Electronic dimmers**, especially popular in d ing rooms, regulate the brightness of incand cent and tungsten halogen lights, allowing y to create an informal, relaxed atmosphere – they save energy.
- **Motion sensing light switches** turn lights o and off automatically when someone enters room, offering "no-hands" light control for ha ways, bedrooms and other areas where light are inadvertently left on, or as part of your home security system.
- **Electronic timers** provide precise, automatic on-off control of light fixtures and are often used for home security. For instance, they wi turn specific lights on automatically at dusk and off at "bedtime" making your house app occupied when you are away from home.

How to compare cost and efficien

Why would you buy a $20 compact fluorescent bulb rather than a $1 incandescent? Because th more costly efficient bulbs produce more lumen (light) per watt (electricity used) than the cheape bulbs, and last up to 10 times longer, making th a better bargain in the long run. The two basic pieces of information you need to find the best and the right product are right on the package.

Watts – This is often the only number people look for when buying a light bulb. It tells how much power the bulb consumes, but nothing about the light output.

Average lumens – This is the amount of light given off by the bulb.

Efficiency = Lumens per watt

For example: A 75-watt incandescent bulb uses 75 watts of electricity and provides 1,200 lumens. A 20-watt compact fluorescent uses 20 watts of electricity (one-fourth the amount) and provides the same amount of light (1,200 lumens). Which is the better deal?

Combined cost of lighting – To determine the real cost of lighting, add the cost of the bulb (initial cost plus replacements) and the electricity cost. For example, compare the operating cost of a single 20-watt CFL and a 75-watt incandescent (over the life of the bulb).

	Bulb cost (Initial x replacement)	Electricity (10,000 hours)	Total
75W Incand.	$1 X 13 = $13	$48.75	$61.75
20W Com. fluor.	$20 X 1 = $20	$13.00	$33.00

How to evaluate your lighting

To evaluate the lighting you presently have, take a tour of your home in the evening, turning on the lights as you go from room to room. Are you getting the light you need in each area? First, you should know that lighting generally falls into one of three categories:

Accent lighting is used to highlight specific objects, such as art work, shelves or plants. It can also illuminate wall surfaces in a soft wash of light or accentuate the texture of the surface.

Task lighting directs light to specific activity areas. Lights under cabinets to illuminate kitchen work surfaces, or a reading lamp next to that favorite chair are two common examples of task lighting.

Ambient lighting distributes light broadly throughout a space, such as the traditional single ceiling fixture located in the center of a room. Ambient lighting by itself is still adequate for general activities that are not visually demanding, but will not give you the quality of light you need for reading or sewing.

To make sure you get the lighting you want, choose and locate accent fixtures first, then choose and locate task lighting fixtures. If additional light is still needed, use ambient lighting fixtures.

Putting the strategies to work

Experts know that the right lighting can dramatically change the look and feel of a room. Following are several ideas that you can use to enhance the beauty of your home and increase your lighting energy efficiency – room by room.

In the kitchen …

- Mount low profile fluorescent tube fixtures under cabinets above work surfaces to provide the light you need for food preparation and clean-up. They should be mounted as close to the front of the cabinet as possible to avoid counter-top glare. A good choice is a thin T5 fluorescent tube lamp that consumes 8 watts per linear foot.
- Use recessed ceiling fixtures or track lighting with 45-50 watt T-H PAR 38 flood lamps over a work island or open counter. (See Sidebar: Spot or Flood lights – What's the difference?)
- Use a pendant fixture over the table equipped with either a 60-watt incandescent lamp or a T-H "A" lamp on a dimmer switch. Better yet, a 20-watt compact fluorescent approved for dimmer use.
- For ambient lighting, use ceiling-mounted fluorescent fixtures with tri-phosphor lamps (choose 3000K or 3500K for medium to warm color). Select a ceiling fixture that directs some of the light up toward the ceiling. This minimizes the "gloomy" look of a dark ceiling and can make a small room feel larger.

In the dining room …

- Combine a decorative fixture or chandelier over the dining table with other fixtures which provide ambient light. A hanging fixture by itself usually becomes a source of glare if it is used to brightly illuminate the entire room.
- Use T-H PAR spot lamps in recessed ceiling or track fixtures as accent lighting to highlight a painting or to illuminate a buffet. For distances of six feet or less, 45-50 watts per lamp is sufficient. Beyond six feet, use 75-watt lamps. Better yet, try one of the compact flood lamps.
- Install separate dimmer switches for each type of lighting to provide maximum flexibility.

Spotlights or flood-lights – what's the difference?

When purchasing bulbs for recessed ceiling or track lighting fixtures, you may have to choose between "spot" or "flood" versions of the same bulb. You will be disappointed if you mistakenly purchase the wrong type.

Spot lights direct the light more intensely into a smaller, tighter beam. Use spot lights primarily for accent lighting applications, but never for ambient lighting.

Flood lights disperse the light into a wider beam – lighting a broad area less brightly than a spot light. Flood lights are most often used for ambient ceiling or track fixtures.

Safety code for closets!

According to the state's safety code, certain precautions must be taken when using incandescent bulbs in closets. For instance:

- The lamp must be enclosed. You cannot use an open bulb in a closet.
- Surface mounted incandescent fixtures must be at least 12 inches from shelves or clothing rods.
- Lamps in recessed fixtures and surface-mounted fluorescent fixtures must be 6 inches or more from shelves or clothing rods.

Contact your local building inspector if you have further questions.

In the living room or family room …

- Use CFLs with high light-output bulbs in reading lamps next to furniture. The circular style (30-watt) with an electronic ballast will give you 2200 lumens – equivalent to a 150-watt incandescent bulb.
- Use T-H PAR flood lights in recessed fixtures over game tables or activity areas. Add dimmer switches for maximum light control and energy savings.
- Try a technique called "wall washing" for ambient lighting. Look for the new recessed ceiling fixtures made for compact fluorescent lamps or use a decorative wall bracket with fluorescent tube fixtures. Directing the light toward ceilings and walls reflects light throughout the room. (Note: This is not as effective in rooms with dark colored walls.)

In the bedroom …

- Soft, ambient lighting is usually adequate and attractive for bedrooms, with an additional reading lamp or two at the bedside.
- In a master or guest bedroom, install one ceiling fixture using two 15-20 watt compact fluorescents or 60-75 watt incandescents.
- In a child's room add automatic wall switches that turn lights off when the room is unoccupied.
- Adding a light in the closet can be useful when you want to avoid lighting the entire room. Although, be aware that there are safety code restrictions to placing incandescent bulbs too close to clothing or other combustible materials. (See side bar.)

In the bathroom …

- Use dimmable fixtures with incandescent or tungsten-halogen lamps on both sides of the mirror for the best cosmetic lighting. A second-best choice would be lighting above the mirror.
- Provide lighting above bath and shower areas for safety – especially in larger bathrooms – with recessed or surface mounted ceiling fixtures.

Outdoor lighting

Recent developments in outdoor lighting have greatly expanded the possibilities to increase the safety, security and beauty of your property as well as saving energy. Following is a descriptio of some of the products available, along with s gestions for how to use them.

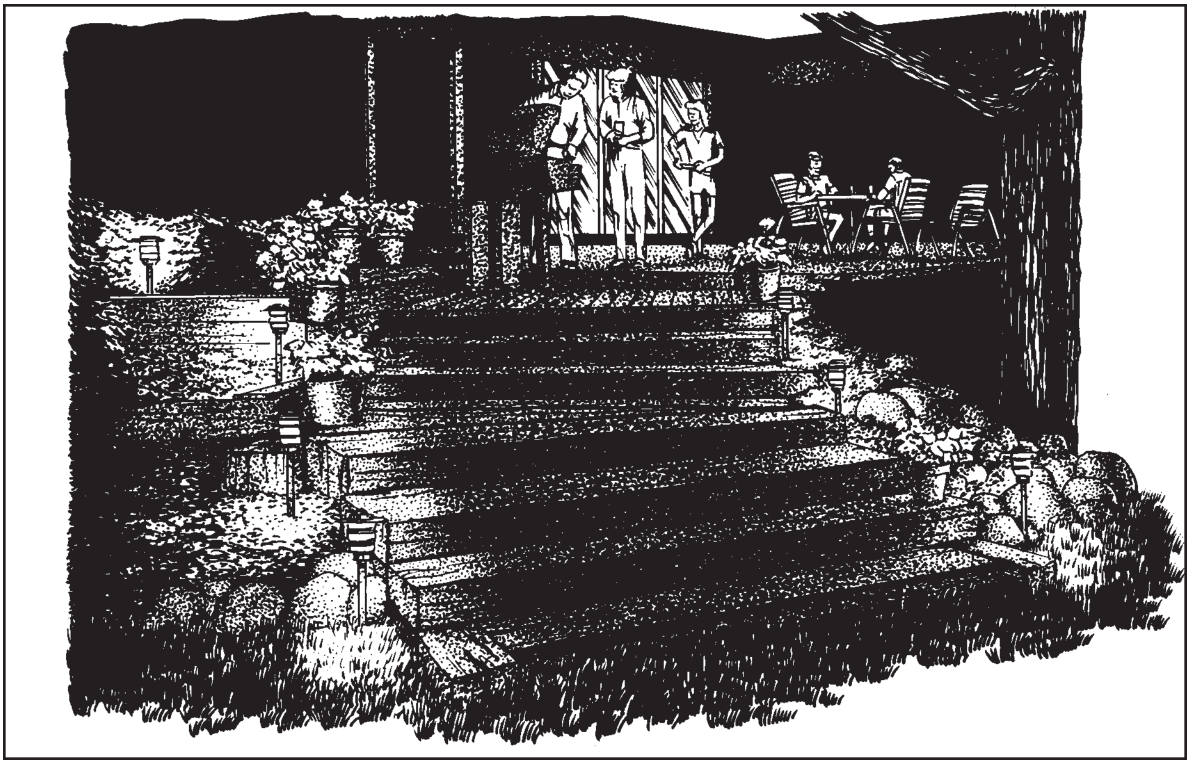
Low-voltage incandescent or tungsten-halog lamps are popular for landscape lighting beca of their safety (less shock hazard), low energy cost, and they are easy to install. They run on 12 volt current rather than the standard 120 vo and operate off transformers, similar to doorbe You can choose among tier lights, mushroom lights, floodlights, or high and low walk lights, many of which come mounted on stakes that push into the ground. Put these lights on motio detectors or programmable timers to limit thei on-time and energy consumption.

PAR lamps are available in 120 volt spot and flood lights appropriate for outdoor lighting. Lo for the tungsten-halogens which provide more light, last longer, and consume less power than regular incandescent reflector lamps.

Insect lights just don't work! Designed to trap and kill insects (specifically mosquitoes), they would seem a good choice for an outdoor light Minnesota. Unfortunately, these lights usually attract mosquitoes in such large numbers that kill rate is ineffective. Ultraviolet and blue wav lengths attract insects – yellow repels them. Hi pressure sodium lights, with their golden yello hues, would be a good choice. Or, any bulb wit yellow coating or a fixture with a yellow lens would also work as a repellent.

Gas lights with mantles that are heated with n ural gas are sometimes still used for outdoor de rative lighting, although state law currently forb installing any new gas lamps. These lamps give out very little light for the energy consumed. A the cost of operating a gas lamp is expensive (f to 16 times as much as incandescents) since the lamp is on 24 hours a day. If you already have gas light, it would be more economical to conv it to an incandescent fixture by purchasing a lo voltage conversion kit with photocell.

High pressure sodium lamps (HPS), characte ized by a "golden" or yellow colored light, prov a highly efficient means to light wide areas, su as yards and building perimeters, and are a go replacement for older "blue-green" mercury va



Tip:

Enhance the beauty, safety and security of your property with energy efficient outdoor lighting.

High pressure sodium lighting is a good highly efficient replacement for your outdoor lighting.

lighting. Recently, fixtures have been developed for high pressure sodium lights that mount on the sides of outdoor buildings – which would be a good choice for lighting areas around garages, barns or other out buildings. In animal production barns it is important to use fixtures rated for high humidity and damp conditions.

Photovoltaic cells directly convert sunlight into electrical energy. Photovoltaic (PV) light systems collect and store energy from the sun, then use the energy to produce light at night. They are most useful as an outdoor summertime light, especially for those who would otherwise have to pay for extending electrical wiring into their yards or to a remote site. Although, be aware that all PV light kits are not created equal. Before purchasing, make sure the operating characteristics are compatible with Minnesota winter temperatures and the intended use.

Lighting Controls are useful outdoors as well as indoors.

- Automatic timers allow you to set lights to go off and on at specific times.
- Photocell controls, sensitive to natural light levels, will automatically turn lights on at dusk and off at dawn.
- Security spot lights turn on and off when someone steps in and out of its range.

All controls must be protected from the weather. Be sure to check operating temperature range before installing any outdoor lighting equipment. Higher quality products often include circuitry which compensates for Minnesota's temperature ranges.

Seal recessed lighting fixtures to prevent air leaks

Heated indoor air leaking through unsealed recessed light fixtures causes numerous problems, in addition to heat loss. When warm air leaks into the unheated attic, water condenses and can drip back onto the light fixture and ceiling. The heated air, by creating warm spots on the attic roof, also can cause ice dams along the roof eaves. Air leaks in ceiling fixtures also can contribute to the loss of needed combustion air, contributing to dangerous backdrafting of the furnace and water heater. All recessed light fixtures are not created equal. IC rates recessed lights can have an airtight box built around them, then covered with insulation. Proper insulation is very important. For recommended measures to ensure air tightness, contact the Energy Information Center.

Common Replacements

Pole-mounted fixtures to replace older mercury vapor heads:

Mercury vapor	HPS	Light output (lumens)
250 watt	150 watt	14,400
175 watt	100 watt	8,850
100 watt	50 or 75 watt	3600-5600

Replacements for entrance, wall-mounted, or decorative post-top lighting:

Incandescent	HPS	Light output (lumens)
500 watt	100 watt	8,850
300 watt	70 watt	5,600
200 watt	50 watt	3,600
135 watt	35 watt	2,000

Lighting types and how they work

Incandescent means "glowing with heat." Light is produced when the electric current heats the bulb's filament. The bulbs are usually made of clear or frosted glass, screw into a "medium base" socket, generally last from 750 to 1000 hours, and emit a warm white light.

Reflector lamps (R-lamps), most often seen in recessed ceiling or track lighting fixtures, are incandescents, halogen or compact fluorescent with the bulb partially coated with aluminum or silver to direct more light out of the bulb. An improved version, with more precise reflectors, is the PAR lamp (parabolic aluminized reflector). They are available in spot or flood light versions and are also used outdoors for security or decorative lighting.

Tungsten-halogen is another type of incandescent that provides a whiter light and a higher light-output over time than regular incandescents. Unlike earlier versions, the new T-H lamps will operate on standard household current (120 volts) and screw into standard sockets. The new bulb design, encasing the tungsten filament within a glass capsule, has also eliminated the health risks associated with ultraviolet radiation.

Fluorescent lamps produce light by activating light-emitting phosphors. The electric current flowing between the electrodes at each end generates ultraviolet radiation, which in turn excites the phosphors coating the inside of the tube. Since this produces very light heat for the amount of light produced, they are more efficient. All fluorescent lights require a ballast to convert ordinary household current to the high voltage needed t start and maintain the light. Magnetic ballasts heavier and will flicker at start-up, while electr ic ballasts are lighter and provide an "instant c feature. When operated properly, fluorescent lamps will last from 9,000 to 20,000 hours.

High intensity discharge (HID) lamps produce light by passing an electric current through ga under pressure. Because they can operate throughout a wide temperature range they are often used for outdoor security lighting. Mercu vapor lights, known for their blue-green color, have been used for outdoor lighting since the 1930s. They are being superseded, however, by high pressure sodium lamps which produce a golden colored light and are very efficient.

Lighting Do's and Don'ts

Don't use "long life" incandescent bulbs – they may last longer, but put out much less light tha regular incandescent, while still consuming the same amount of electricity. In places where cha ing a bulb is difficult and a long life lamp is desired, consider a compact fluorescent which l ten times longer than a standard incandescent.

Do purchase energy-efficient incandescent bul instead of the standard 60, 75 and 100 watt bu They will save 5 to 10 watts per bulb with littl no change in light output.

Don't use devices containing "diodes" (coin siz disks that install into lamp sockets) that claim increase the life of a bulb. With these devices, light output drops dramatically, and they may pose a safety hazard since they cause an electr fied portion of the lamp base to be exposed.

Don't purchase expensive "full spectrum" fluor cent lamps which exaggerate the benefits of ul violet light. Currently there are no products on market made to fit standard household fixture which provide the suggested therapeutic value offered by true full-spectrum lights.

Do make sure your fixtures have been tested f safety and listed by an independent agency, su as UL or ETL. Look for one of these designatio on the fixture before purchasing.

Do check the light output in "lumens" on the package when you buy different brands of bul

Some off-brands may have a lower purchase price, but provide less light output.

Do ask for the new "air tight" fixtures when purchasing new recessed ceiling fixtures. They will greatly reduce air leakage (and heat loss) through the ceiling.

Where to buy efficient light bulbs:

- Check at discount retail department stores, home improvement centers and hardware stores – let the managers know you're interested. There's nothing like demand to stimulate supply.
- Most commercial lighting supply houses, which supply lamps to businesses, will also sell to the public. Look in the yellow pages under "Lighting."
- Check with your local electric utility. Many either sell efficient light products or offer rebates as part of a conservation program that can delay or eliminate the need for new power plants.

Where to find more information:

- *Planning and Designing Lighting*, Edward Effron (1986)

An excellent book for anyone interested in setting up an efficient, attractive lighting system. Easy to understand with excellent photographs and illustrations.

- Basic how-to guides from Time/Life, Ortho or Sunset

These guides provide a good explanation of basic lighting concepts and selection of light sources.

- For individual help with lighting design, check with a lighting specialty store where they often have trained designers on staff – although be aware that energy efficiency may not be their top priority. Look under "Lighting Consultants" in the yellow pages.

These manufacturers have design information for consumers available on their web pages.

http://www.sylvania.com/
http://www.lighting.philips.com/

The Lighting Resource
P.O. Box 48345
Minneapolis, MN 55448-0345
http://www.lightresource.com/

Lighting Research Center
School of Architecture,
Rensselaer Polytechnic Institute
Troy, NY 12180
http://www.lrc.rpi.edu/

HOME ENERGY GUIDE

TECHNIQUES TACTICS & TIPS

Wood Heat

Minnesota Department of Commerce Energy Information Center

Wood is a widely used heating fuel: approximately a third of all Minnesota homes use wood at least occasionally to provide space heat. Wood can be an effective and economical source of heat, provided all necessary steps are taken to ensure efficiency, environmental health, and fire safety.

Selecting and installing a stove

Chimneys and stovepipes

Operating a stove properly

The purpose of this guide is to describe the necessary steps to achieve an efficient and safe wood fire. They start with the basic decision on the type of equipment to use, followed by instructions on proper installation, maintenance, and operation. The guide deals only with stoves and does not address wood burning furnaces, boilers, or open fireplaces.

A few words of caution: If you are considering becoming a first-time user of a wood stove, you should examine your own expectations of what a wood stove will provide. Although the new stoves on the market are much improved over previous models, they are not a substitute for a central heating furnace.

Types of wood stoves

A variety of wood stoves are in use today, but anyone who wants to heat efficiently and cleanly with wood will want a model that meets Environmental Protection Agency (EPA) standards. Most new stoves sold today must meet these efficiency and emission standards (some small manufacturers are not required to meet EPA standards), which represent considerable progress over the standards of stoves sold just a little more than a decade ago. The certified wood stoves of today have efficiencies ranging from 63 to 78 percent, compared to 40 to 50 percent for stoves sold in the 1970s and '80s. They also emit less than one-tenth the amount of smoke.

Three types of residential stoves meet these standards: catalytic, high tech non-catalytic, and pellet burners.

Catalytic stoves. These stoves use a catalytic combustor that operates on the same principle as the catalytic converter in your car. In a conventional wood stove, as much as 30 percent of the fuel can go up the chimney as unburned fuel when the unit operates at moderate temperatures – between 500º and 600ªF. For complete combustion, the conventional stove must burn at nearly 1,000°F. The catalytic stove, in contrast, obtains complete combustion at approximately 500°F. This increased combustion gives more "mileage" from the fuel and produces less air pollution, particularly on mild autumn and spring days when the chimney's natural draft is reduced and the building heat loss is low.

In operating a catalytic stove, make sure that the combustor is ignited. The stove should burn moderately for 10 to 30 minutes until it reaches the 500° required for ignition. It is best to check the temperature using a catalyst temperature probe (see Figure 1), which may come with the stove or be purchased for $15 to $45. Maintain the temperature within 1,200° to 1,400°F; significant damage will occur above 1,800°F.

Only untreated, well seasoned wood should be used and the combustor should never be scraped, jarred, or blown out with an air compressor. If

Related Guides:
Home Heating
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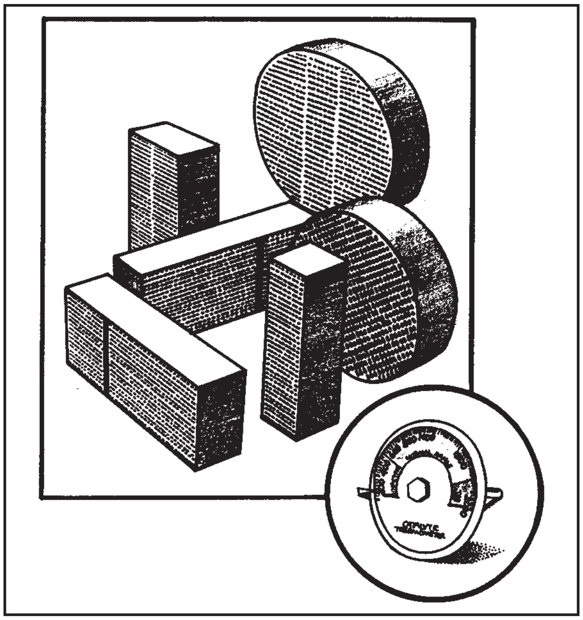


Figure 1
Catalytic combustors come in a variety of shapes and sizes; bottom right is a typical temperature probe with an operating range of 500° to 1800°F.

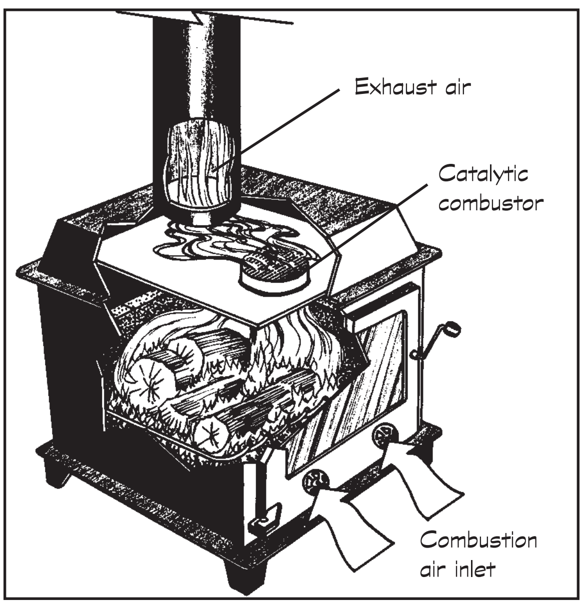


Figure 2
Catalytic stoves are highly efficient and allow the most user control.

these guidelines are followed, the combustor should be effective for up to 12,000 hours (about three to six years). If increased smoke comes out of the chimney at low burning temperatures, or if the unit has difficulty maintaining a temperature of 900 to 1,000°, the combustor probably needs replacing. The EPA requires that combustors should be easy to inspect and replace and that they be guaranteed for at least two years. The cost of replacing a combustor ranges from $60 to $200, but in a two year period, the combustor should save more than that in fuel savings.

It is possible to retrofit a stove with a catalytic combustor, but the add-on devices are usually only about half as effective as a new unit with a built-in combustor.

A well designed catalytic stove (Figure 2) costs from $900 to $1,700 and offers the following benefits:

- Produces 80 to 90 percent less pollution at low to moderate temperatures.
- Provides combustion efficiency of at least 72 percent when the stove is new.
- Uses 25 to 30 percent less firewood.
- Requires less frequent chimney cleaning because the clean burn produces less creosote.
- Provides increased safety because less creosote means less chance of chimney fire.
- Allows the user to throttle down the fire manually.

High tech non-catalytic wood stoves. Many EPA certified stoves achieve high rates of combustion without a catalytic combustor. Non-catalytic stoves (Figure 3) are slightly less efficient, with ratings from 63 to 75 percent, and they often require more frequent refueling. They offer advantages, however: a wider choice of fuel can be used and there is no need to replace a catalytic combustor. A "non-cat" stove costs from $500 to $2,000, depending on size and style, and offers the following features:

- Preheats incoming air to keep combustion temperatures higher for more complete combustion.
- Stationary baffles direct gases back to the combustion zone for more complete burning.

- Pre-heats secondary air to reignite gases and reduce fuel loss up the chimney.
- Stationary air inlets ensure adequate air for combustion.
- Small fireboxes lined with firebricks maintain high temperatures in the combustion zone.

Pellet stoves. Some EPA certified stoves burn fuel pellets manufactured from wood or other biomass. With a pellet stove (Figure 4), you load batches of fuel into a hopper. A motorized auger, controlled by a dial or thermostat, then moves the pellets into the stove as needed. A small fan controls air flow in the combustion process.

When buying wood pellets, pay attention to the ash content, making sure the particular ash level is compatible with your stove. Most stove dealers should be able to give you information on where to obtain the appropriate pellets.

Pellet stoves, like the other stove types, have advantages and disadvantages. The fans and augers consume only about 150 watts of electricity, but they can't provide heat during power outages. Fuel must be obtained from a dealer, rather than a local wood lot (pellet prices, however, have remained fairly stable). Pellet stoves are more expensive than most wood stoves, costing from $1,500 to $2,000, but they don't require expensive chimney systems. They also have controlled air-to-fuel ratios that allow them to achieve nearly complete combustion, and their excellent heat transfer ranks them among the lowest in smoke emissions and highest in efficiency.

Basically, pellet stoves are a good choice if you do not have a reliable wood supply or if you want to avoid installing a more expensive chimney system.

Selecting a wood stove

In deciding which of the three types of stove is right for you, consider the initial cost, the operating cost (including fuel and electricity for fans), availability of fuel, appearance, and insurance company requirements. Talk with your instance agent before buying a stove. Some insurance companies will not provide coverage for a home that is heated by a wood stove. Others will, but some charge very high rates. You may need to have your installation inspected by the insurance company before your

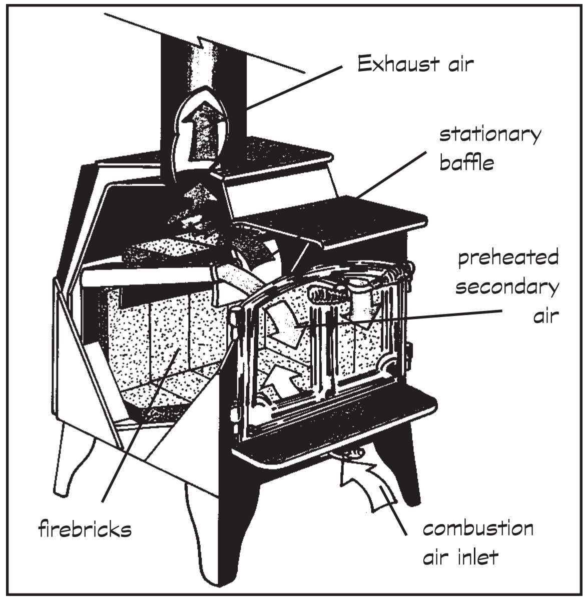


Figure 3
High tech non-catalytic stoves are slightly less efficient than catalytic stoves, but are also less expensive and will adapt to a wider choice of fuel.

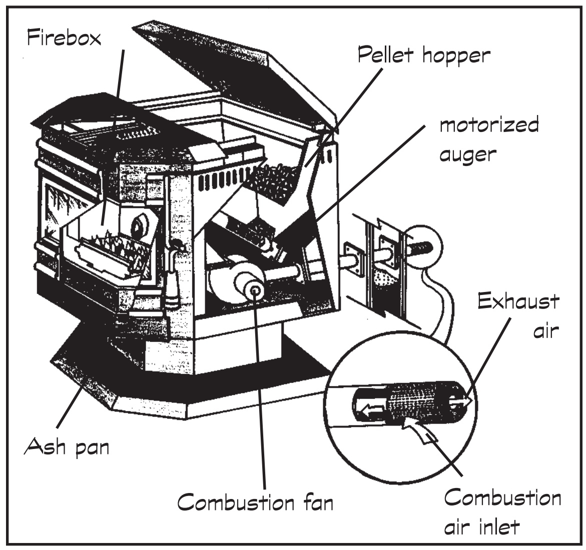


Figure 4
In pellet stoves, a fan pulls air into the firebox through a two-part pipe system that also acts as a heat exchanger as the outgoing exhaust air warms the incoming air for combustion.

Tip

Wood stoves must be installed to meet fire protection standards.

Before buying and installing a wood stove

- Check first with your insurance agent to make sure you can continue to have house insurance and what the rates will be.
- Next, apply for a permit from your local building inspection department. The Minnesota Uniform Fire Code requires solid fuel burning appliances to be listed and installed in accordance with the terms of their listing. If your appliance is not listed, it can be approved provided it is installed in accordance with the Minnesota Fire Code. Your local building inspector can provide you with the specific requirements of the Fire Code.
- If you reside in rural Minnesota or in a community that does not have a building inspector, you can discuss the specific installation procedures, clearances from combustible materials, and other requirements of the Minnesota Fire Code by consulting with your insurance company or local fire department or by writing the State Fire Marshal Division, Minnesota Department of Public Safety, 444 Cedar Street, Suite 100M, St. Paul,, MN 55101-2156.

coverage begins. Before buying a stove, you should also check with your local municipality regarding required permits and inspections.

Emissions, efficiency and safety certification. Make sure the stove you are buying meets efficiency, emissions and safety standards. As previously noted, all new stoves from major manufacturers sold today must meet EPA efficiency and emissions standards. The stoves carry both a permanent and temporary label. The temporary label compares the stove's average performance with the emissions standards, allowing you to compare one stove to another. The permanent label (Figure 5) shows emissions and efficiency levels for a range of heat output. Use this information to select the proper size unit for the space you will be heating (see section, "Sizing a stove," below).

The Minnesota Uniform Fire Code requires solid fuel burning appliances to be listed and installed in accordance with the terms of their listing. Unlisted appliances can be approved by your local authority, but they must be installed in accordance with standards of the National Fire Protection Association (NFPA) Standard 221.

A listed stove has been tested to meet standards established by organizations such as the International Council of Building Officials (ICBO) and Underwriters Laboratory (UL). Safety labels must be permanently affixed to a "listed" stove. The label must state the name of the laboratory that conducted the safety test, the test standards that were applied, and basic installation requirements for the stove. If there is no label permanently attached, the stove has not been tested and is not listed for safety.

Features promoting efficiency, clean-burning. Whatever type of stove you buy, look for features that promote clean, efficient burning, such as:

- Air supply ducts that allow incoming air to be preheated and directed into the active flames, increasing combustion efficiency.
- Baffle plates designed to regulate the flow within the stove, directing incompletely burned gases to the active fire, resulting in better combustion efficiency.
- Firebox insulation sufficient to maintain an average firebox temperature slightly above the 1,000°F. required for clean combustion and to protect the metal surfaces of the firebox. Without firebox insulation, the fire is continuously cooled as the heat escapes to the room air surrounding the stove.
- Secondary air supply that allows for the combustion of unburned gases that would otherwise escape up the chimney and pollute the air.

Other design features. These design features do not affect efficiency of the stove, but should be kept in mind for your own convenience.

- An ash pan eases removal of ashes.

- A circulating stove, which uses fans to circulate warm air, is safer for households with children, since its hot stove surfaces are covered by an outer jacket. A radiant stove has no outer jacket and heats principally by infrared radiation (heat moving by long wavelength from one surface to another), considered by some to be a more comfortable form of heating.
- Door location and size determine how easily the wood fuel can be loaded.
- Firebox size determines how big the wood pieces can be.
- A cast iron stove versus plate steel is largely a matter of preference. Cast iron may crack, plate steel may warp, and both may corrode, but neither has been proven more efficient than the other. Top quality tight-fitting construction, rather than material, is the key to a good stove.
- There are two types of automatic damper controls – one type completely opens or shuts the damper and the other makes gradual adjustments. Each has its own characteristics, but average room temperatures are the same for comparable systems.
- Liners, either firebrick or steel, extend the life of the firebox and are much less expensive to replace than the stove itself. They also provide thermal mass to store heat.

Sizing a stove. The most common mistake in sizing a stove is selecting a stove that is too large for the area to be heated. The primary factors involved in sizing a stove are:

- Volume of open area to be heated.
- Your home's insulation and weatherization level.
- Rate of infiltration.
- Average outside temperature during the heating season.
- Location of stove within the building.
- Volume and placement of combustion air/draft air inlet.

Call the Energy Information Center and talk to one of our energy specialists for advice on the proper size stove. Then contact a wood dealer or contractor with experience in your area, and with your style of home.

AVERAGE EMISSIONS AND EFFICIENCY PERFORMANCE

SMOKE 3.4 grams/hour — DEQ Catalytic Standard 6 until 07/88, 4 after 07/88

EFFICIENCY 78.1 % — No DEQ Standard

HEAT OUTPUT RANGE
11,609 to 53,093 Btu/hour

Manufacturer: Travis Industries, Inc. Kirkland, WA
Model: LOPI® Flex/95 Series — Design No: FS, FL, LX

(Performance may vary from test values depending on actual home operating conditions)

Pursuant to OAR 340-21-100 to 190, this woodheating appliance is certified as meeting The Oregon Department of Environmental Quality emission standard and is approved for sale in the State of Oregon.

Figure 5
A permanent label relating emissions and efficiency to heat output is required by the EPA and helps in sizing the stove.

Installing a wood stove

Proper installation of a wood stove is necessary for clean and efficient operation and – even more important – for safety. Improperly installed wood stoves and chimneys are the major cause of house fires. As previously noted, Minnesota has a statewide fire code requiring wood stoves to be installed according to certain standards. *Always follow manufacturer's instructions, paying particular attention to clearance from combustible surfaces. It is advisable to have professional help in installing a stove.*

Location. Your stove should be located in a frequently used area such as the living room or family room. When you have decided on a location, inspect the structural support under the floor on which the stove will be placed to make sure it is adequate.

The best place for a stove is in the center of the room, where it can radiate heat in all directions. The worst place to put a stove is in a closet or alcove. Stoves are often placed in the middle of

Tip

Cheating on clearances means a certainty of a fire!

an outside wall and vented straight up through the roof. In any case, installation requires proper clearance between stove system surfaces and their surroundings to keep your home safe from fire. Remember, heat transfer from the walls of the stovepipe and chimney, as well as from the stove, must be considered.

Clearances from combustible materials. Constant exposure to heat lowers the temperature at which a material will begin to burn. A joist or rafter too close to the chimney walls, or a wall stud too close to the stove and its stovepipe, will overheat and ignite. *Clearances are specified by safety codes to prevent overheating of combustible materials by keeping them at a safe distance. Cheating on these clearances means a certainty of a fire!*

Each manufacturer of listed stoves is required to specify minimum clearances. These clearances vary, depending on the construction of the stove. When installing your wood heating system, you must follow the manufacturer's instructions. If you install a stove for which there are no instructions, you should observe the clearances listed in the section on Clearances later in this guide.

A noncombustible material is defined as that which will not ignite or burn when subjected to flame or intense heat for long periods of time. Steel, iron, brick, tile, concrete, slate, and glass are noncombustible.

All walls containing wood framing are combustible, including plaster and sheetrock walls on wood lath or wood studs. Nearly every wall and ceiling in residential buildings contains wood. If you are unsure about your home, assume that the wall or ceiling is combustible and maintain proper clearance.

A floor is considered noncombustible if it is concrete, slab-on-grade design, or solid concrete with steel or concrete–but not wood–supports. An existing masonry hearth extension is noncombustible if no wood forms have been left in place below it, and if stove placement allows at least 18 inches of hearth extension in front of the loading door.

All wood floors, carpets and synthetic materials are considered combustible and must be protected in an approved manner. Other combustible materials include furniture, draperies and newspaper.

All stoves and stovepipes require a minimum clearance to unprotected combustibles on top and on all sides of the wood stove.

No clearance is needed for stoves or stovepipes to noncombustible walls (i.e., concrete walls or dirt floors). It is a good practice, however, to allow six inches or more for good air circulation and heat dissipation.

Protective or clearance reduction systems. Installing a clearance reduction system will reduce heat transferred to the combustible surface, allowing specific clearances to be lowered. See the section on Clearances later in this guide.

A variety of prefabricated clearance reduction systems are available through wood stove and fireplace dealers. Always look for the safety listing and make sure the system is designed to be used with a wood stove. The manufacturers of these tested and listed accessories provide specific installation instructions that must be followed.

Floor protection. *All combustible floors must be protected.* The only base on which a stove can be installed without special protection is a noncombustible floor or properly built hearth extension. Manufacturers of listed stoves usually specify the type of material required for floor protection and these materials should be used. If the manufacturer does not specify a material, you may purchase one or more of the safety tested and listed prefabricated stove boards on the market.

Chimneys and stovepipes

A chimney is a critical part of your wood heating system. It carriers smoke out of the house, and creates the suction or draft necessary to draw air to the fire. A well designed chimney allows the stove to operate cleanly, producing a minimum amount of smoke and creosote. Chimneys used with wood stoves must meet "all fuel" standards, also called "Class A."

The chimney connector or vent connector is commonly known as the stovepipe. It connects the stove to the chimney. A stovepipe has a single metal wall and may not pass through a well, ceiling, attic, closet, or any concealed area.

Studies show that most house fires related to wood heaters originate around the chimney or

Smoke and carbon monoxide detectors

Smoke detectors should be installed on every level of your home. If you burn wood, it is even more important to have working smoke detectors. Fires can smolder for hours, long after flames have gone out.

The majority (75 percent) of fatal fires occur in residences. Most fatal fires occur between midnight and 6 a.m., when people are asleep. Smoke detectors are designed as an early warning device to awaken sleeping residents.

Test all smoke detectors monthly and change batteries once a year. Make sure you and your family have an early warning that allows you time to escape in the event of a fire.

A backdrafting stove can be as lethal as an actual fire. The Energy Information Center recommends installing a CO detector alarm. Make sure it has a UL listing.

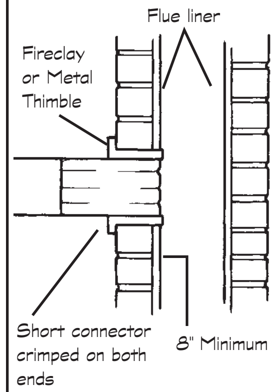
stovepipe. According to the U.S. consumer Product Safety Commission, house fires involving chimneys are caused primarily by creosote buildup in the chimney (creosote is soot and tar produced as a by-product of wood burning), metal chimneys too close to combustibles, chimney failure, improper construction or deterioration of a masonry chimney, and improper installation of a chimney connector (stovepipe). *Before building or installing a chimney and stovepipe, therefore, it is very important to contact the fire marshal's office and the local building code officials for information on making your system safe.*

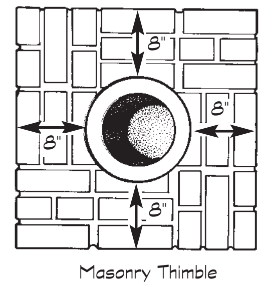
Chimney height is critical to creating proper draft and meeting fire codes. The chimney should extend at least three feet above the point where it exits the roof, and should be a minimum of two feet higher than any part of the roof within ten feet. (See The 3-2-10 rule.)

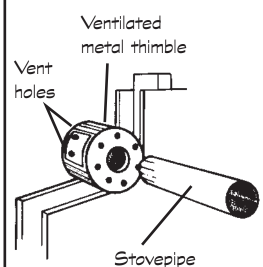
For safety reasons, the stovepipe should be as short as possible, but installations with five feet or so of pipe are acceptable. Keep in mind that the most trouble-free system will have few, if any, horizontal pipe sections and elbows. A vertical stovepipe gives the best possible draft and allows creosote and soot to fall back into the stove to be burned. Long runs of stovepipe should be avoided because they inevitably fill up with soot, ash, and creosote.

Thimbles. Use a metal or fire clay thimble when passing a stovepipe through noncombustible walls. The thimble should be permanently cemented into the masonry chimney and extend through the chimney wall to the inner face or liner, but not beyond. Push the short section of stovepipe, crimped on both ends, into the thimble and secure it with high temperature sealant. The stovepipe should extend as far as possible into the thimble, but should not stick out into the chimney.

If you must vent through a combustible interior or exterior wall, contact the fire marshal for instructions. A stovepipe may never pass through a ceiling, closet, or concealed area. For these situations a "Class A" chimney is required. Once the stovepipe connects to the chimney, it must remain a chimney from that point on. No further use of stovepipe is allowed.







Thimbles must be used to connect the stovepipe to the chimney.

Tip

All chimneys need to be regularly inspected for deterioration and creosote buildup

Masonry or metal chimney. Whether to have a metal or masonry chimney depends on a number of factors: both types have advantages and disadvantages.

Metal chimneys are often less expensive than masonry chimneys and are more adaptable to installation in existing houses. *(Some insurance companies, however, will not approve coverage for homes with a metal chimney; be sure to check with your insurance company before installing a metal chimney.)* Most masonry chimneys require the work of an experienced mason and are usually built at the same time as the house.

A chimney cap is often added to keep out rain. On masonry chimneys, a flat plate of steel or concrete is most often used, but more stylish ceramic and metal caps are available. Caps for safety tested and listed manufactured chimneys are also available.

Masonry chimneys are very durable, and some homeowners consider them more attractive than prefabricated chimneys. In addition, massive interior masonry chimneys will store heat longer and continue to release this heat to the room long after the wood fire has subsided.

Masonry chimneys also have disadvantages. They are expensive to build and more difficult to inspect and maintain than prefabricated chimneys. In addition, masonry chimneys are often built on an exterior wall, reducing heating efficiency. This exposure to cold outdoor temperatures leads to greater heat loss and higher accumulations of creosote deposits.

Whether you have a masonry chimney built or plan to use an existing one, safety should be your prime consideration. A masonry chimney is a very heavy structure that must be able to withstand many years of use, including occasional chimney fires in which temperatures may reach 2,700°F.

Safety do's and don'ts when connecting a wood stove to a masonry chimney:

- Make sure the stove will have enough air for combustion and proper draft for that size chimney.
- Check the general condition of an existing chimney. Look for loose bricks and cracks in the mortar that might allow creosote to leak out or sparks to escape and ignite creosote or dry structural wood. Have a competent mason do any needed repairs.
- Many older homes have chimneys that are in good structural shape but do not meet "all fuel" or "Class A" requirements. A typical example is a chimney constructed of four-inch brick without a fire clay liner. These chimneys can be made safe by lining them with safety listed liners.
- Each wood burning appliance must have its own flue (a fireplace is considered an appliance). If you have more than one fireplace, check the chimney to make sure that a flue exists for each appliance.
- Frequently in older homes an existing masonry chimney may have served more than one appliance in various rooms. It is critical to locate and seal these unused entry ports or breachings. Unused breachings are often covered with a thin metal "pie plate" cover. They may be hidden by paneling or plaster, especially if the house has been remodeled. Unused breachings should be sealed using masonry and fire clay mortar to make the former entry port as sound as the rest of the chimney.

Chimney inspection and cleaning. *All chimneys require regular inspection for deterioration and creosote buildup.* A correctly built chimney can settle and require repair within time – a poorly built chimney is dangerous from the start. The chimney should be inspected and cleaned at least once a year, as often as biweekly if you use your wood stove daily. Remember that a cleanout opening is required and provides a convenient way to remove creosote after a cleaning. The opening should be more than two feet below the stovepipe entry port, should be made of ferrous metal frame, and must have a door designed to remain airtight when the stove is in use. Also, disassemble the smokepipe and inspect it.

Clean the chimney when creosote deposits are one-quarter inch thick. Inspect the flue at both the stove end and chimney top. Remember that cooler surfaces will have the thickest creosote deposits (these are usually near the top).

You can have a professional clean your chimney or you may choose to clean it yourself. Wear a

The 3-2-10 Rule

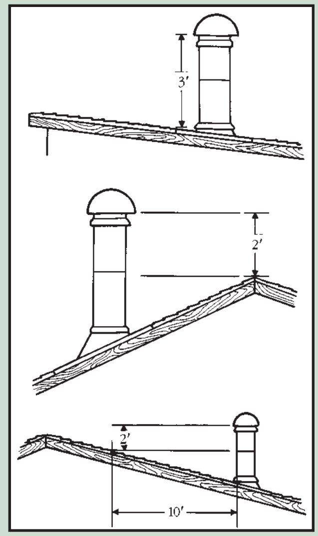
Chimney height is critical to creating proper draft. The chimney must extend at least three feet up from the roof and be at least two feet higher than any part of the roof within ten feet, measured horizontally. Measurements are made from the high side of the roof to the top of the chimney wall.

If your chimney is 10 feet or more from the roof ridge, you may use Table 1 directly. If the ridge is closer than ten feet, calculate the proper height by using the numbers from Table 1 in the following formula: Roof slope x Distance to ridge + 2 feet = Required height above the roof.

For example, a chimney on a 5/12-slope roof located 6 feet from the ridge requires: (5/12 x 6 ft.) + 2 feet = 4 feet, 6 inches above roof.

Table 1
Minimum Chimney Heights

Roof slope*	Height above the roof ridge 10 feet or more from chimney
Flat	3'
1/12	3'
2/12	3'8"
3/12	4'6"
4/12	5'4"
5/12	6"2"
6/12	7'
7/12	7'10"
8/12	8'8"
10/12	10'4"
12/12	12'



* Roof slopes are given in feet of rise per 12 feet of run. A 6.12 slope rises 6 feet per 12 feet of horizontal run.

protective mask and goggles and gloves and use a quality steel-bristle brush. You'll also need to clean the inside of the stove and stovepipe. If you suspect leaks or cracks in your stove system, call in a professional to perform a leak test. If any leaks are found, have them repaired immediately.

Chimney fires. Chimney fires occur when creosote on the inside of a chimney wall burns. Chimney fires most likely occur during a very hot fire, as when cardboard is burned or when normal wood is burned at a very high rate. A crackling sound is often the first sign of the over-firing of a stove that precedes a chimney fire. As intensity grows, the stovepipe may shake violently, air will be forcefully drawn in through the stove, and the stovepipe will glow red hot. Another symptom of overfiring a stove is "back-puffing" – small puffs of smoke come out of the combustion chamber making a sound similar to a heavily muffled backfire from a car. A tall plume of flame and sparks will rise from the top of uncapped chimneys.

When a chimney fire starts:

- Close the dampers. This limits the air supply.
- Call the fire department immediately.
- Wet down the roof and other outside combustibles to prevent fires started by shooting sparks and flames.
- Keep a close watch on all surfaces near the chimney.
- Have the chimney inspected before using it again. Cracks or openings caused by the fire may allow creosote to leak out. The next chimney fire may include your attic or interior walls near the chimney.

Combustion air

Minnesota building codes require an outdoor air inlet to ensure adequate air for combustion. The size of the inlet required depends on a number of variables, such as type and height of chimney and heating size of the stove. Check with your building code officials. Without an outdoor air supply, your stove will take combustion air from the room, creating the potential for dangerous backdrafting of noxious gases and smoke into the house. With inadequate combustion air, your central furnace or water heater may backdraft toxic gases, even if the fireplace or stove appears to work properly.

Some wood stoves draw outdoor air directly into the stove, ensuring an adequate combustion air supply and reducing unwanted infiltration. If your stove does not have this feature, call the Energy Information Center and ask for a copy of "Combustion Air." This guide provides suggestions on how to install an air inlet. For a new home built to meet energy codes, an air inlet is absolutely necessary.

Fuel

The kind of wood you burn affects the amount of heat you receive. Density and moisture content of the wood affect combustion. Dense species, such as white oak, that are well seasoned or dried have higher energy content per volume. Burning "green" wood, which contains as much as 50 percent water, consumes a large amount of heat energy simply to dry the wood prior to combustion. "Dry" wood has 15 to 20 percent moisture by volume.

Wood fuel is measured in cords, with one standard cord equaling 128 cubic feet (4x4x8), assuming the wood is cut into four-foot lengths and ranked. If the sale is of sawed wood, a cord is 100 cubic feet when ranked, or 160 cubic feet when thrown irregularly or loosely into a truck. If the wood is sawed and split, a cord is 120 cubic feet when ranked and 175 cubic feet when thrown loosely into a truck.

Sometimes wood is measured in "face cords," or by other definitions often smaller than a standard cord, so make sure you know what you are buying. You should get a bill of sale with clearly defined volumes.

What not to burn:

- Household garbage can produce noxious and corrosive gases and can foul a catalytic combustor.
- Newspaper and magazines cannot be used in catalytic stoves because the lead and other metals in the ink can foul the combustor.
- Plastics and junk mail can cause lethal fumes.
- Treated or painted wood can produce very toxic and sometimes explosive gases.

Operating a stove properly

To ensure that you operate your stove efficiently and safely, observe the following guidelines.

- Start the fire with dry kindling and with air inlets and dampers wide open for maximum air.
- Add two or three pieces of dry wood, keeping air inlets and dampers open.
- *Never light or rekindle a stove fire with kerosene, gasoline, or charcoal lighter fluid – the result can be fatal.*
- In 15 or 20 minutes, when the fire is burning well, adjust air inlets and dampers to control the speed of burn.
- Add only one or two pieces of firewood at a time and provide more air each time fuel is added.
- Determine if you have the proper air supply by checking what's coming out of the chimney – dark smoke indicates that more air is needed. A note of caution: most manufacturers of cast iron stoves recommend keeping the first fires small to break in new stoves gradually. New stoves always smoke on start-up as the paint and sealants are heated. Be prepared to open windows and doors for ventilation.
- Always keep a fire extinguisher and a bucket of sand nearby. Use water on wood stove fires only in extreme emergencies: the water turns to steam, scatters hot ash everywhere, and can crack cast iron stove parts and damage chimneys.
- When refueling, open the damper and air inlet fully a minute before opening and loading. For airtight stoves, this is especially important because a sudden rush of air into the chamber can trigger a small explosion. Escaping gases can seriously burn anyone standing nearby. All openings in operating stoves should be opened slowly, and the operator's face should be kept well back from the stove for a few minutes after opening.
- When refueling a non-catalytic stove, allow the fire to die down some before adding fuel. For effi-

Creosote

The perfect fire would result in complete combustion, leaving only water and carbon dioxide as by-products. In reality, combustion is never complete. Hot unburned gases, solid particles, and tar-like liquids go up the flue as smoke. As these substances contact the cooler flue surface, they condense. When the water evaporates, it leaves behind a tar called creosote, which builds up fire after fire into a crusty black layer.

Creosote is the enemy of wood stove users and should be feared because it causes chimney fires. It is highly flammable. Large deposits can block the flue and make the stove smoke.

The amount of creosote formed in the flue depends upon a number of factors. The smokier the fire, the bigger the creosote problem. When the fire is hot enough, creosote burns along with the other organic compounds in the wood. A good hot fire is a cleaner fire. It is easier to make a small fire hot. Don't overload the stove; it will smoke.

High moisture wood leads to higher creosote formation because the water vapor inhibits combustion, making the fire cooler and smokier. The more smoke, the more creosote. The cooler temperatures result in more condensation on the flue walls.

With any type of wood, smoke production is greatest when fresh wood is added or when air supply is turned low. At these times, combustion efficiency is lowered, and heavier smoking results.

Increased levels of creosote are associated with soft woods because of their high resin contents. Dry hardwoods have a reputation of generating the least amount of creosote. Seasoned softwood fires will not produce large amounts of creosote.

To cut down on creosote deposits:

- Burn well-seasoned hardwood.
- Keep a brisk burning small fire and maintain a good draft.
- Add small loads of wood frequently rather than fewer large loads.
- Don't ever add a full charge of green wood—this will generate large amounts of creosote.
- A wood stove fire should not be allowed to smolder all night long, with exception of a catalytic stove fire. For the catalytic stove, add the last charge of wood an hour before retiring, reducing the wood to cleaner burning charcoal.
- Minimize the length of stovepipe connecting the stove to the chimney.
- The only way to remove creosote safely is by a traditional chimney cleaning that includes scraping the creosote from the inside of the flue.

ciency and safety you are better off burning many small hot fires rather than one slow-burning fire.

- Don't overfire the stove: red hot stovepipes and overheated fuels will warp and damage the metal and can cause chimney fires.
- Watch out for handles and surfaces too hot to touch with bare hands.
- Before going to bed or leaving the house, always check to see that the stovepipe damper is open, the stove door securely fastened, and combustibles a safe distance from the stove.
- Ashes that seem cool may contain hot embers, so always place ashes in a metal container with a tight fitting lid. (Leave an inch or more of ashes to protect the bottom of the firebox.) Place the container on a noncombustible floor or on the ground, 15 feet away from combustible materials or buildings until final disposal. Embers/ashes can remain hot for up to 48 hours.
- Do not put green or wet wood on top of the stove to dry it. Such a practice is very dangerous. Do not, in fact, put anything on top of the stove unless it is absolutely fireproof.
- Do not store flammable liquids near the stove, especially in workshops, basements, and garages.
- If you suspect you have a problem, call the fire department as soon as possible. Don't take a chance with fire.

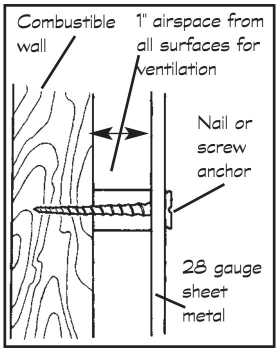


Diagram 1

Noncombustible spacers such as stacked washers, small pipe, tubing, or electrical conduit can be used to create the 1" air space. Masonry walls may be attached to combustible walls using wall ties. Do not use fasteners directly behind stovepipe or stove.

Clearances for Wood Stoves and Stovepipes

(Clearances listed in this section should be observed when manufacturer's installation instructions are not available. When manufacturer's instructions are available, compare the recommended clearances with those listed here. Using the larger clearance will provide a margin of safety.)

Unprotected floors, walls and ceilings. All stoves require a minimum 36-inch clearance to unprotected combustibles above and on all sides of the stove. A single wall stovepipe must have an 18-inch clearance to combustible walls and ceilings, measured at right angles to the pipe.

No clearance is needed to noncombustible walls (i.e., concrete). It is good practice, however, to allow six inches or more for good air circulation and dissipation of heat.

The only base on which a stove can be installed without special protection is a noncombustible floor or properly built hearth extension. Such a base should extend at least 18 inches on all sides of the stove.

Protected walls and ceilings. A wood stove and stovepipe may be placed closer than 18 inches to a combustible material if the material is protected in an approved manner with either a home-built or a prefabricated clearance reduction system.

The two most common types of home-built clearance reduction systems use 24 gauge sheet metal (galvanized steel, aluminum, copper) or 3-1/2-inch (4-inch nominal) thick masonry wall. Either of these materials must be spaced out one inch from the combustible surface; that is, they must be anchored to the combustible surface so that there is a one-inch air space between the sheet metal or masonry and the combustible material. (Diagram 1) With sheet metal, noncombustible spacers are used to maintain the one-inch air space. With a masonry wall, metal wall ties and furring strips, if needed, are used to anchor the brick to the wall. Do not place the spacers or wall ties directly behind the stove or stovepipe. The one-inch air space must be maintained around the entire perimeter of the clearance reduction system so that air flows freely and removes heat. This prevents the combustible surface from catching fire. Sheet metal or masonry attached to the wall without this air space offers no protection and cannot be considered a clearance reduction system.

A variety of prefabricated clearance reduction systems are available through wood stove and fireplace dealers. Always look for the safety listing and make sure the system is designed to be used with a good stove. The manufacturers of these tested and listed accessories provide specific installation instructions that must be followed.

Table 2 shows some clearances required using clearance reduction systems on walls and ceilings. These clearances are also depicted in Diagrams 2, 3, 4, and 5. (Masonry clearance reduction systems are used only on walls, not ceilings.)

The clearance reduction system must be centered behind or above the stovepipe to protect the wall or ceiling. The system should extend 36 inches past the stove in height and width, measured diagonally. If the stove is placed farther from the wall than the minimum distance required, the width and height of the clearance system can be determined by measuring from the side and top edge of the stove to the unprotected wall. This distance should be no less than 36 inches. The larger the distance between the stove or stovepipe and the wall, the smaller the clearance reduction system needs to be.

Some manufacturers may specify greater clearances. For a complete listing of clearances using clearance reduction systems, contact the fire marshal's office.

Protected floors. All combustible floors must be protected, and many types of materials are available for floor protection. Manufacturers of listed stoves usually specify the type of material required and, if available, these materials should be used. If the manufacturer does not specify a material, you may purchase one or more of the safety tested and listed prefabricated stove boards on the market.

Floor protection should extend 18 inches in front of the loading door to prevent damage to the floor from sparks, embers, ash or radiant heat. It should also extend 18 inches or more on the remaining sides of listed stoves, unless the manufacturer specifies a greater amount. (Diagram 6) An unlist-

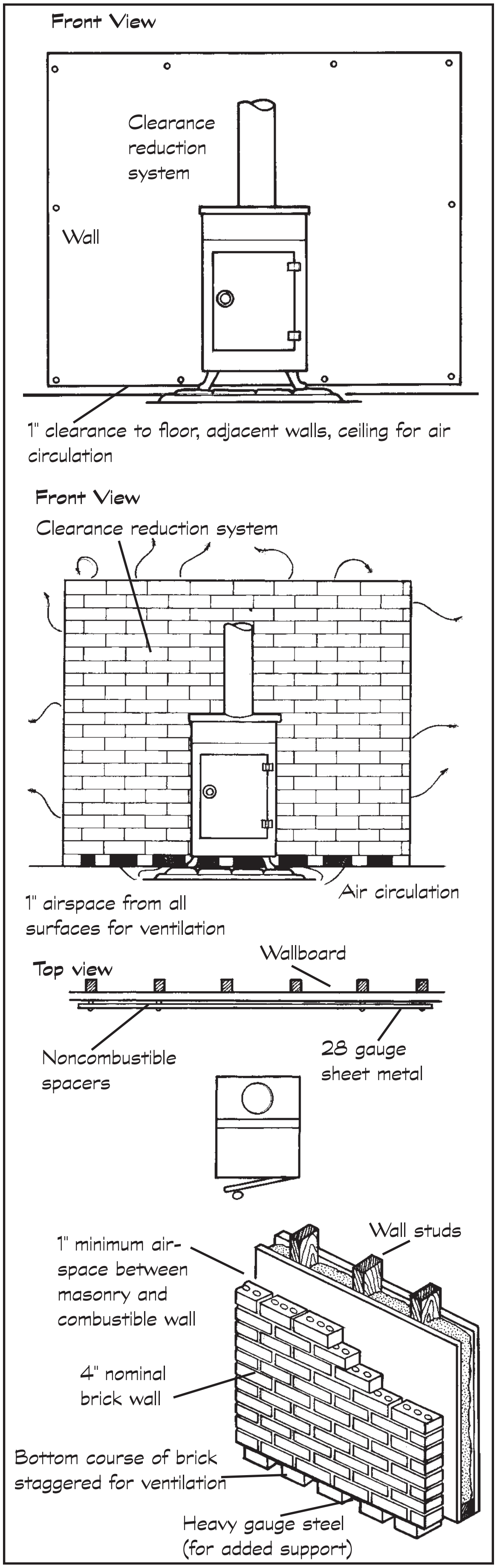


Diagram 2

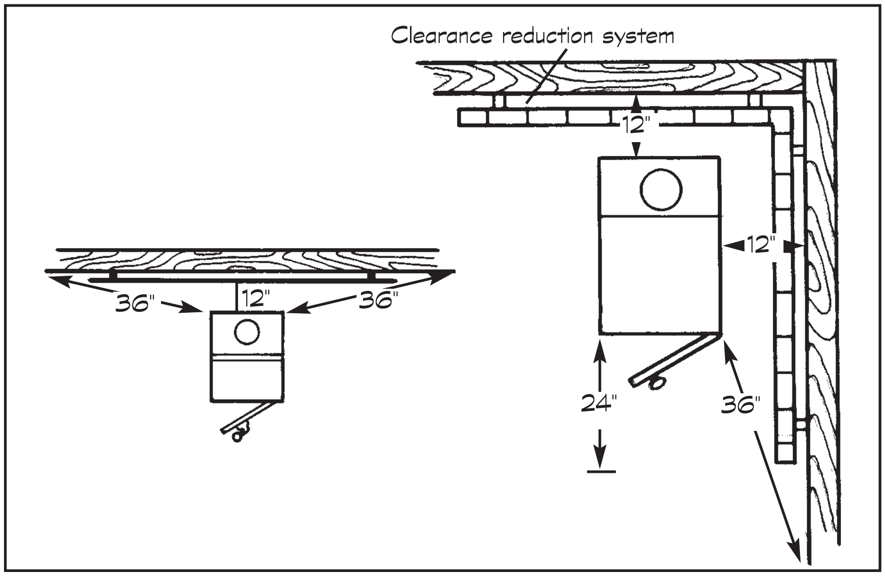


Diagram 3

A clearance reduction system using sheet metal or masonry can be used to safely shorten the distance from stove to combustibles.

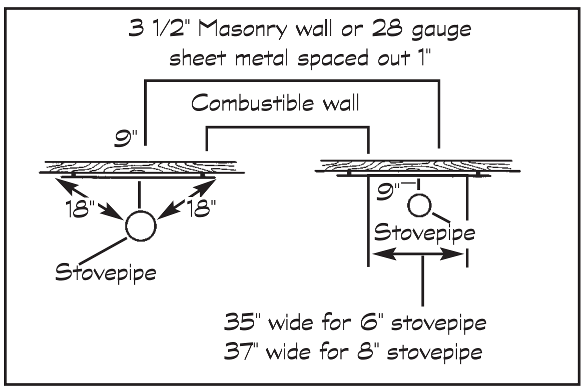


Diagram 4

For a 6-inch stovepipe, the protection must be 35 inches wide; 37 inches for an 8-inch stovepipe.

Diagram 5

Without protection, a stovepipe can be no closer than 18 inches to combustible ceilings and walls. By using a masonry wall or sheet metal, spaced out 1 inch from the combustible wall, the distance from stovepipe to combustible surfaces can be shortened to 9 inches.

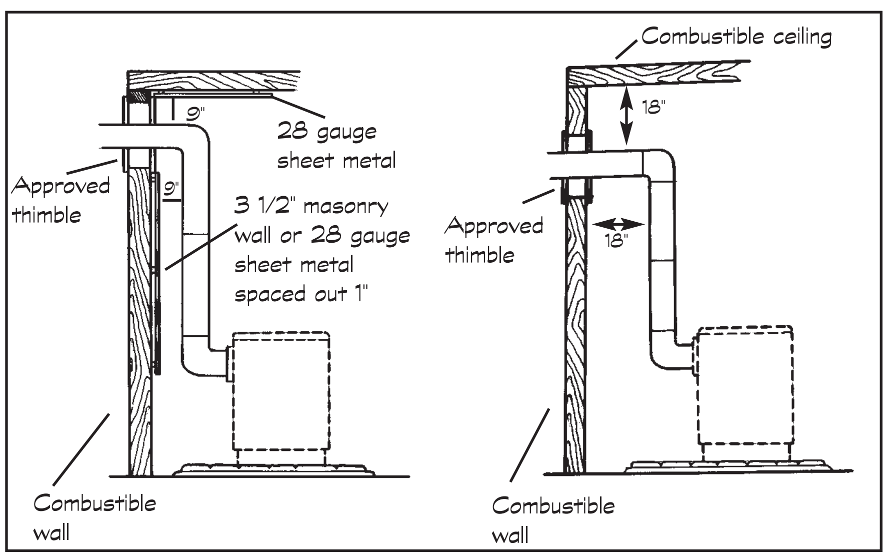


Table 2: Clearances Using Clearance Reduction Systems

TYPE OF PROTECTION	WOOD	STOVEPIPE
3-1/2" masonry wall spaced out 1"	12"	–
24 gauge sheet metal spaced out 1"	12"	9"
Prefabricated system	per manufacturer's specifications	

Notes:
1. These clearances are from the side of the stove or stovepipe to a parallel combustible surface.
2. Loading doors require at least a 24-inch clearance, even with clearance reduction systems or noncombustible surfaces, to allow room for loading the stove..
3. There must be at least a 36-inch clearance from the top of the stove to any unprotected combustible surface.
4. Use these clearances or those contained in the manufacturer's instructions, whichever is greater.
5. Masonry clearance reduction systems are used on walls, not ceilings.

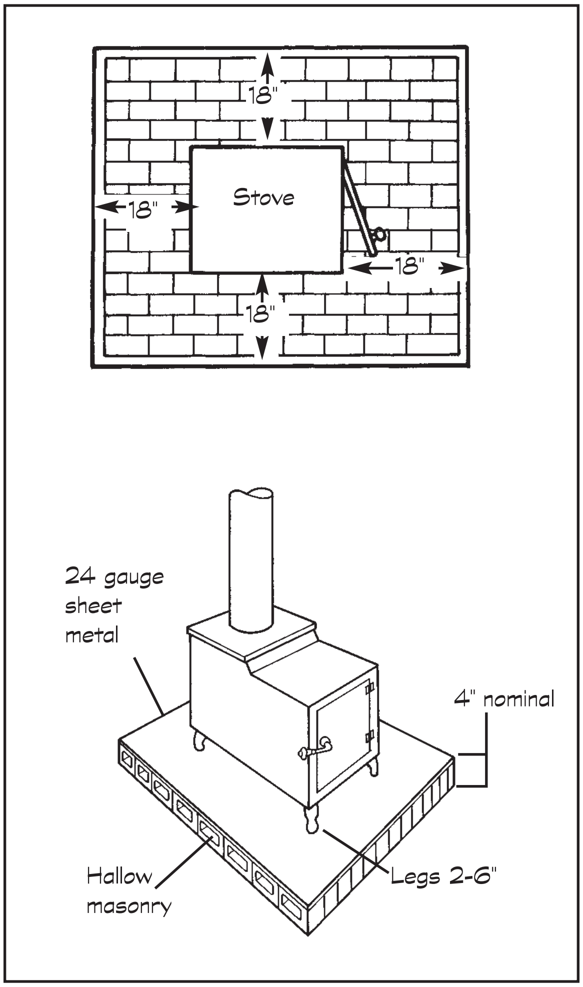


Diagram 6
Floor protection must extend 18 inches in all directions. For stoves with 2-6 inch legs, you must protect a combustible floor with 4-inch masonry arranged to allow air flow, and 24 gauge sheet metal.

ed stove requires 18 inches of floor protection on all sides, including the loading and ash doors.

If more than one safety listed prefabricated stove board is needed to meet the clearance requirements, the junction between the stove boards should be made using either a safety tested and listed stove board adapter or a strip of 24 gauge sheet metal four to six inches wide.

The type of floor protection recommended depends on stove leg length. Stoves with legs less than two inches in height must rest only on floor protection as specified by the manufacturer, safety tested and listed prefabricated stove boards, or a noncombustible floor.

If your stove has legs two inches or greater in height, you are also allowed to use a combination of sheet metal and masonry. The arrangement of sheet metal and masonry for floor protection depends upon the length of the stove legs:

- Stoves with legs two inches to six inches: Floor protection can consist of four-inch (nominal) hollow masonry laid to provide air circulation through the layer and covered with 24 gauge sheet metal. Another layer of masonry may be laid over the sheet metal for aesthetic appeal.
- Stoves with legs higher than six inches: Floor protection can consist of closely spaced masonry units of brick, concrete or stone that provide a thickness of not less than two inches. Such masonry must be covered by or placed over 24 gauge sheet metal.

If you use a combination of sheet metal and masonry for floor protection, be sure that each stove leg has a firm, solid footing.

HOME ENERGY GUIDE

TECHNIQUES TACTICS & TIPS

HOME LIGHTING

Minnesota Department of Commerce Energy Information Center

It may seem hard to beat the familiar Edison light bulbs we've all used for years. They are inexpensive, fit our fixtures, are readily available and give off a pleasing light we are all comfortable with. However, the standard incandescent light bulb is terribly inefficient. Because almost all of the electricity going into it is lost in heat, the light bulb is actually much better at providing heat than light.

New lighting products are not only more energy efficient, they offer many more possibilities to improve the quality of lighting our homes, indoors and out.

This guide looks at some of the new technologies for residential lighting, identifies four basic strategies you can apply, then provides specific examples of how to put the new strategies into practice throughout your home – room by room.

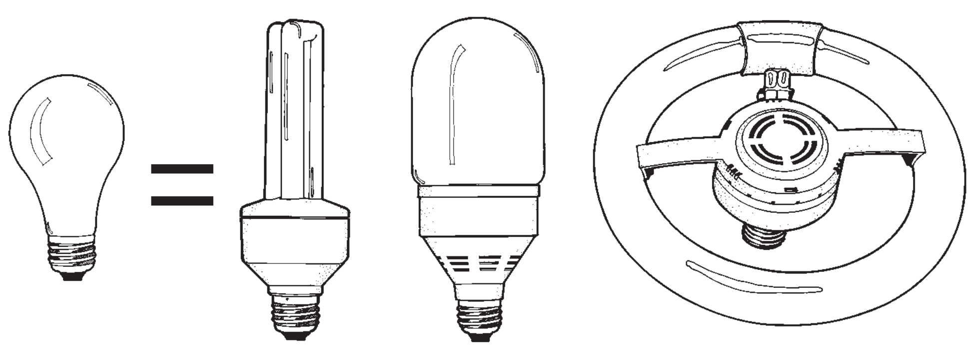
The new technology and how to use it: 4 strategies

Strategy 1: Replace standard incandescent lamps with compact fluorescent lamps.

No other new product in the lighting industry has had as great an impact as the compact fluorescent lamp (CFL). Modern CFLs have taken the best aspects of fluorescents – high efficiency and long life – while eliminating traditional problems of

Common replacements

Incandescent Watts (lumens)	Compact Fluorescent Watts (lumens)
60 (900)	16 (900)
75 (1200)	20 (1100-1200)
100 (1750)	30 (1600-1800



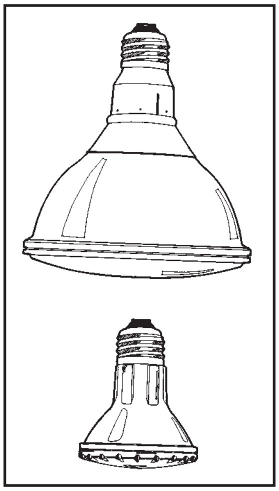
Compact fluorescents come in a variety of shapes and sizes to fit different fixtures.

Related Guides:
Low Cost/No Cost Ideas
ApOpliances

Tip:

Look for the new "improved color" fluorescent tubes.

If you can't use fluorescents, look for "halogen" bulbs.



Tungsten-halogen reflector lamps are 40% more energy efficient than incandescent R-lamps.

poor color, flicker and noise. Although, CFLs still cannot be used with dimmer switches and do not perform well outdoors in cold weather. They cost an average of $10 to $25 per bulb, but they last ten times longer than incandescents and use 60 to 75 percent less electricity!

You'll get the most benefit by switching to CFLs wherever you use high wattage incandescent lamps more than three hours per day – often in the kitchen and family room.

Strategy 2: Replace standard incandescent ceiling fixtures (especially in the kitchen and laundry area) with fluorescent fixtures equipped with tri-stimulus phosphor lamps.

These lamps provide the energy savings of fluorescent lighting with an improved color that compliments rather than clashes with natural daylight. Kitchen and laundry areas especially need and use lots of light, so look for big savings in these areas.

New fluorescent 4-foot tube lights coated with "tri-stimulus" phosphors come in three shades of white. The "warmest" of the three provides a light similar to incandescents and is designated 3000K. The lamp with the coolest hue has a rating of 4100K. There is also a lamp with an "in-between" color designation of 3500K. When offered the choice, most people prefer 3000K and 3500K lamps. Although these lamps cost about $8 to $12, with a rated life of 20,000 hours they can be expected to last over ten years in most residential applications.

Strategy 3: Replace incandescent spot and flood lights with "T-H" PAR lamps. Or better yet, manufactured compact fluorescent flood lamps. These new arrivals on the market in R-30 and R-40 sizes can easily replace many floods and spots used indoors.

In places where fluorescent lighting cannot be used, tungsten-halogen (T-H) lighting is a good choice. Basically a more efficient form of incandescent lighting, although not as efficient as fluorescent, "halogen" bulbs produce a crisp light that brings out the true colors of your furnishings – which makes this lamp popular with decorators.

In your recessed ceiling or track lighting fixtures, a good replacement is the T-H PAR (parabolic aluminized reflector) lamp, which is 40 percent more energy efficient than incandescent reflector lamps, costs about $7 and can be used indoors and outdoors.

You can also get T-H "A-line" (traditional style) bulbs to replace standard 60, 75 and 100 watt incandescents. They use 12 percent less electricity and have a longer life – at an average cost of $3 per bulb.

Strategy 4: Use automatic lighting controls in dining rooms, hallways – or anywhere!

A number of easy to install lighting controls are available that will increase your lighting flexibility, your home security and your energy savings.

- **Electronic dimmers**, especially popular in dining rooms, regulate the brightness of incandescent and tungsten halogen lights, allowing you to create an informal, relaxed atmosphere – and they save energy.
- **Motion sensing light switches** turn lights on and off automatically when someone enters a room, offering "no-hands" light control for hallways, bedrooms and other areas where lights are inadvertently left on, or as part of your home security system.
- **Electronic timers** provide precise, automatic on-off control of light fixtures and are often used for home security. For instance, they will turn specific lights on automatically at dusk and off at "bedtime" making your house appear occupied when you are away from home.

How to compare cost and efficiency

Why would you buy a $20 compact fluorescent bulb rather than a $1 incandescent? Because the more costly efficient bulbs produce more lumens (light) per watt (electricity used) than the cheaper bulbs, and last up to 10 times longer, making them a better bargain in the long run. The two basic pieces of information you need to find the best buy and the right product are right on the package.

Watts – This is often the only number people look for when buying a light bulb. It tells how much power the bulb consumes, but nothing about the light output.

Average lumens – This is the amount of light given off by the bulb.

Efficiency = Lumens per watt

For example: A 75-watt incandescent bulb uses 75 watts of electricity and provides 1,200 lumens. A 20-watt compact fluorescent uses 20 watts of electricity (one-fourth the amount) and provides the same amount of light (1,200 lumens). Which is the better deal?

Combined cost of lighting – To determine the real cost of lighting, add the cost of the bulb (initial cost plus replacements) and the electricity cost. For example, compare the operating cost of a single 20-watt CFL and a 75-watt incandescent (over the life of the bulb).

	Bulb cost (Initial x replacement)	Electricity (10,000 hours)	Total
75W Incand.	$1 X 13 = $13	$48.75	$61.75
20W Com. fluor.	$20 X 1 = $20	$13.00	$33.00

How to evaluate your lighting

To evaluate the lighting you presently have, take a tour of your home in the evening, turning on the lights as you go from room to room. Are you getting the light you need in each area? First, you should know that lighting generally falls into one of three categories:

Accent lighting is used to highlight specific objects, such as art work, shelves or plants. It can also illuminate wall surfaces in a soft wash of light or accentuate the texture of the surface.

Task lighting directs light to specific activity areas. Lights under cabinets to illuminate kitchen work surfaces, or a reading lamp next to that favorite chair are two common examples of task lighting.

Ambient lighting distributes light broadly throughout a space, such as the traditional single ceiling fixture located in the center of a room. Ambient lighting by itself is still adequate for general activities that are not visually demanding, but will not give you the quality of light you need for reading or sewing.

To make sure you get the lighting you want, choose and locate accent fixtures first, then choose and locate task lighting fixtures. If additional light is still needed, use ambient lighting fixtures.

Putting the strategies to work

Experts know that the right lighting can dramatically change the look and feel of a room. Following are several ideas that you can use to enhance the beauty of your home and increase your lighting energy efficiency – room by room.

In the kitchen …

- Mount low profile fluorescent tube fixtures under cabinets above work surfaces to provide the light you need for food preparation and clean-up. They should be mounted as close to the front of the cabinet as possible to avoid counter-top glare. A good choice is a thin T5 fluorescent tube lamp that consumes 8 watts per linear foot.
- Use recessed ceiling fixtures or track lighting with 45-50 watt T-H PAR 38 flood lamps over a work island or open counter. (See Sidebar: Spot or Flood lights – What's the difference?)
- Use a pendant fixture over the table equipped with either a 60-watt incandescent lamp or a T-H "A" lamp on a dimmer switch. Better yet, a 20-watt compact fluorescent approved for dimmer use.
- For ambient lighting, use ceiling-mounted fluorescent fixtures with tri-phosphor lamps (choose 3000K or 3500K for medium to warm color). Select a ceiling fixture that directs some of the light up toward the ceiling. This minimizes the "gloomy" look of a dark ceiling and can make a small room feel larger.

In the dining room …

- Combine a decorative fixture or chandelier over the dining table with other fixtures which provide ambient light. A hanging fixture by itself usually becomes a source of glare if it is used to brightly illuminate the entire room.
- Use T-H PAR spot lamps in recessed ceiling or track fixtures as accent lighting to highlight a painting or to illuminate a buffet. For distances of six feet or less, 45-50 watts per lamp is sufficient. Beyond six feet, use 75-watt lamps. Better yet, try one of the compact flood lamps.
- Install separate dimmer switches for each type of lighting to provide maximum flexibility.

Spotlights or flood-lights – what's the difference?

When purchasing bulbs for recessed ceiling or track lighting fixtures, you may have to choose between "spot" or "flood" versions of the same bulb. You will be disappointed if you mistakenly purchase the wrong type.

Spot lights direct the light more intensely into a smaller, tighter beam. Use spot lights primarily for accent lighting applications, but never for ambient lighting.

Flood lights disperse the light into a wider beam – lighting a broad area less brightly than a spot light. Flood lights are most often used for ambient ceiling or track fixtures.

Safety code for closets!

According to the state's safety code, certain precautions must be taken when using incandescent bulbs in closets. For instance:

- The lamp must be enclosed. You cannot use an open bulb in a closet.
- Surface mounted incandescent fixtures must be at least 12 inches from shelves or clothing rods.
- Lamps in recessed fixtures and surface-mounted fluorescent fixtures must be 6 inches or more from shelves or clothing rods.

Contact your local building inspector if you have further questions.

In the living room or family room …

- Use CFLs with high light-output bulbs in reading lamps next to furniture. The circular style (30-watt) with an electronic ballast will give you 2200 lumens – equivalent to a 150-watt incandescent bulb.
- Use T-H PAR flood lights in recessed fixtures over game tables or activity areas. Add dimmer switches for maximum light control and energy savings.
- Try a technique called "wall washing" for ambient lighting. Look for the new recessed ceiling fixtures made for compact fluorescent lamps or use a decorative wall bracket with fluorescent tube fixtures. Directing the light toward ceilings and walls reflects light throughout the room. (Note: This is not as effective in rooms with dark colored walls.)

In the bedroom …

- Soft, ambient lighting is usually adequate and attractive for bedrooms, with an additional reading lamp or two at the bedside.
- In a master or guest bedroom, install one ceiling fixture using two 15-20 watt compact fluorescents or 60-75 watt incandescents.
- In a child's room add automatic wall switches that turn lights off when the room is unoccupied.
- Adding a light in the closet can be useful when you want to avoid lighting the entire room. Although, be aware that there are safety code restrictions to placing incandescent bulbs too close to clothing or other combustible materials. (See side bar.)

In the bathroom …

- Use dimmable fixtures with incandescent or tungsten-halogen lamps on both sides of the mirror for the best cosmetic lighting. A second-best choice would be lighting above the mirror.
- Provide lighting above bath and shower areas for safety – especially in larger bathrooms – with recessed or surface mounted ceiling fixtures.

Outdoor lighting

Recent developments in outdoor lighting have greatly expanded the possibilities to increase the safety, security and beauty of your property as well as saving energy. Following is a description of some of the products available, along with suggestions for how to use them.

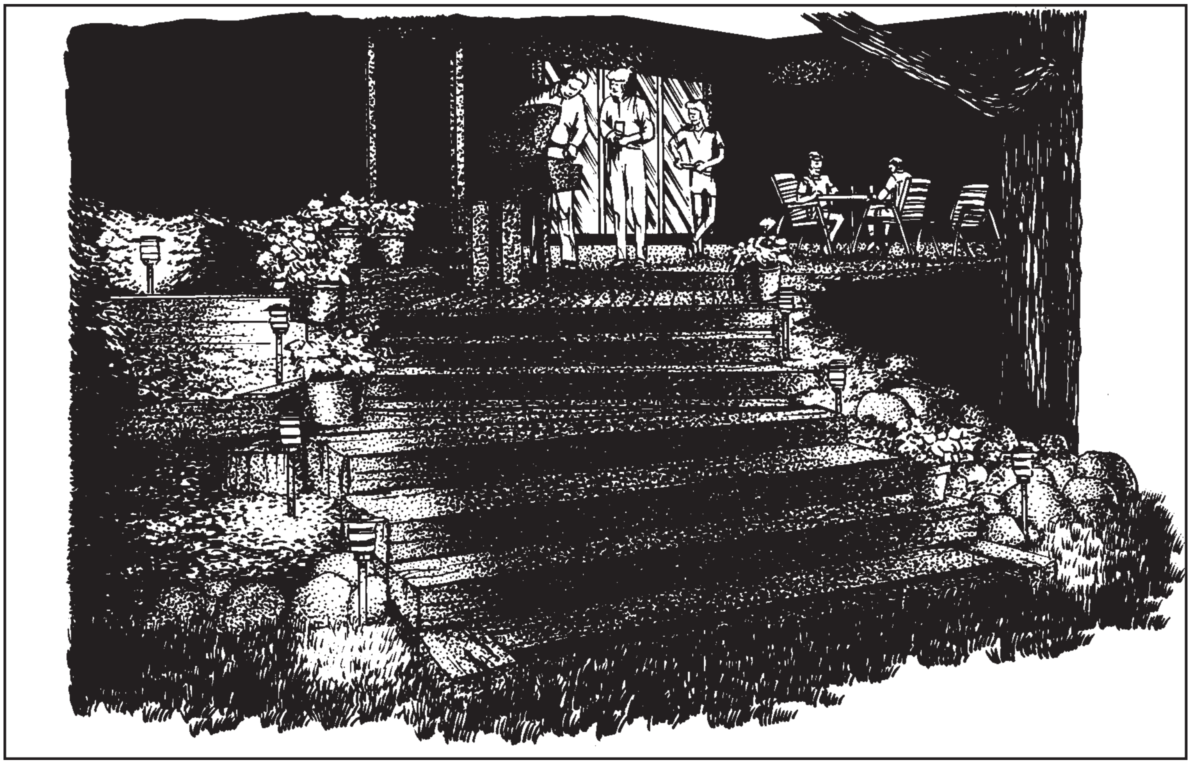
Low-voltage incandescent or tungsten-halogen lamps are popular for landscape lighting because of their safety (less shock hazard), low energy cost, and they are easy to install. They run on a 12 volt current rather than the standard 120 volts and operate off transformers, similar to doorbells. You can choose among tier lights, mushroom lights, floodlights, or high and low walk lights, many of which come mounted on stakes that push into the ground. Put these lights on motion detectors or programmable timers to limit their on-time and energy consumption.

PAR lamps are available in 120 volt spot and flood lights appropriate for outdoor lighting. Look for the tungsten-halogens which provide more light, last longer, and consume less power than regular incandescent reflector lamps.

Insect lights just don't work! Designed to trap and kill insects (specifically mosquitoes), they would seem a good choice for an outdoor light in Minnesota. Unfortunately, these lights usually attract mosquitoes in such large numbers that the kill rate is ineffective. Ultraviolet and blue wave lengths attract insects – yellow repels them. High pressure sodium lights, with their golden yellow hues, would be a good choice. Or, any bulb with a yellow coating or a fixture with a yellow lens would also work as a repellent.

Gas lights with mantles that are heated with natural gas are sometimes still used for outdoor decorative lighting, although state law currently forbids installing any new gas lamps. These lamps give out very little light for the energy consumed. Also, the cost of operating a gas lamp is expensive (four to 16 times as much as incandescents) since the lamp is on 24 hours a day. If you already have a gas light, it would be more economical to convert it to an incandescent fixture by purchasing a low voltage conversion kit with photocell.

High pressure sodium lamps (HPS), characterized by a "golden" or yellow colored light, provide a highly efficient means to light wide areas, such as yards and building perimeters, and are a good replacement for older "blue-green" mercury vapor



Tip:

Enhance the beauty, safety and security of your property with energy efficient outdoor lighting.

High pressure sodium lighting is a good highly efficient replacement for your outdoor lighting.

lighting. Recently, fixtures have been developed for high pressure sodium lights that mount on the sides of outdoor buildings – which would be a good choice for lighting areas around garages, barns or other out buildings. In animal production barns it is important to use fixtures rated for high humidity and damp conditions.

Photovoltaic cells directly convert sunlight into electrical energy. Photovoltaic (PV) light systems collect and store energy from the sun, then use the energy to produce light at night. They are most useful as an outdoor summertime light, especially for those who would otherwise have to pay for extending electrical wiring into their yards or to a remote site. Although, be aware that all PV light kits are not created equal. Before purchasing, make sure the operating characteristics are compatible with Minnesota winter temperatures and the intended use.

Lighting Controls are useful outdoors as well as indoors.

- Automatic timers allow you to set lights to go off and on at specific times.
- Photocell controls, sensitive to natural light levels, will automatically turn lights on at dusk and off at dawn.
- Security spot lights turn on and off when someone steps in and out of its range.

All controls must be protected from the weather. Be sure to check operating temperature range before installing any outdoor lighting equipment. Higher quality products often include circuitry which compensates for Minnesota's temperature ranges.

Seal recessed lighting fixtures to prevent air leaks

Heated indoor air leaking through unsealed recessed light fixtures causes numerous problems, in addition to heat loss. When warm air leaks into the unheated attic, water condenses and can drip back onto the light fixture and ceiling. The heated air, by creating warm spots on the attic roof, also can cause ice dams along the roof eaves. Air leaks in ceiling fixtures also can contribute to the loss of needed combustion air, contributing to dangerous backdrafting of the furnace and water heater. All recessed light fixtures are not created equal. IC rates recessed lights can have an airtight box built around them, then covered with insulation. Proper insulation is very important. For recommended measures to ensure air tightness, contact the Energy Information Center.

Common Replacements

Pole-mounted fixtures to replace older mercury vapor heads:

Mercury vapor	HPS	Light output (lumens)
250 watt	150 watt	14,400
175 watt	100 watt	8,850
100 watt	50 or 75 watt	3600-5600

Replacements for entrance, wall-mounted, or decorative post-top lighting:

Incandescent	HPS	Light output (lumens)
500 watt	100 watt	8,850
300 watt	70 watt	5,600
200 watt	50 watt	3,600
135 watt	35 watt	2,000

Lighting types and how they work

Incandescent means "glowing with heat." Light is produced when the electric current heats the bulb's filament. The bulbs are usually made of clear or frosted glass, screw into a "medium base" socket, generally last from 750 to 1000 hours, and emit a warm white light.

Reflector lamps (R-lamps), most often seen in recessed ceiling or track lighting fixtures, are incandescents, halogen or compact fluorescent with the bulb partially coated with aluminum or silver to direct more light out of the bulb. An improved version, with more precise reflectors, is the PAR lamp (parabolic aluminized reflector). They are available in spot or flood light versions and are also used outdoors for security or decorative lighting.

Tungsten-halogen is another type of incandescent that provides a whiter light and a higher light-output over time than regular incandescents. Unlike earlier versions, the new T-H lamps will operate on standard household current (120 volts) and screw into standard sockets. The new bulb design, encasing the tungsten filament within a glass capsule, has also eliminated the health risks associated with ultraviolet radiation.

Fluorescent lamps produce light by activating light-emitting phosphors. The electric current flowing between the electrodes at each end generates ultraviolet radiation, which in turn excites the phosphors coating the inside of the tube. Since this produces very light heat for the amount of light produced, they are more efficient. All fluorescent lights require a ballast to convert ordinary household current to the high voltage needed to start and maintain the light. Magnetic ballasts are heavier and will flicker at start-up, while electronic ballasts are lighter and provide an "instant on" feature. When operated properly, fluorescent lamps will last from 9,000 to 20,000 hours.

High intensity discharge (HID) lamps produce light by passing an electric current through gas under pressure. Because they can operate throughout a wide temperature range they are often used for outdoor security lighting. Mercury vapor lights, known for their blue-green color, have been used for outdoor lighting since the 1930s. They are being superseded, however, by high pressure sodium lamps which produce a golden colored light and are very efficient.

Lighting Do's and Don'ts

Don't use "long life" incandescent bulbs – they may last longer, but put out much less light than a regular incandescent, while still consuming the same amount of electricity. In places where changing a bulb is difficult and a long life lamp is desired, consider a compact fluorescent which lasts ten times longer than a standard incandescent.

Do purchase energy-efficient incandescent bulbs instead of the standard 60, 75 and 100 watt bulbs. They will save 5 to 10 watts per bulb with little or no change in light output.

Don't use devices containing "diodes" (coin sized disks that install into lamp sockets) that claim to increase the life of a bulb. With these devices, light output drops dramatically, and they may pose a safety hazard since they cause an electrified portion of the lamp base to be exposed.

Don't purchase expensive "full spectrum" fluorescent lamps which exaggerate the benefits of ultraviolet light. Currently there are no products on the market made to fit standard household fixtures which provide the suggested therapeutic value offered by true full-spectrum lights.

Do make sure your fixtures have been tested for safety and listed by an independent agency, such as UL or ETL. Look for one of these designations on the fixture before purchasing.

Do check the light output in "lumens" on the package when you buy different brands of bulbs.

Some off-brands may have a lower purchase price, but provide less light output.

Do ask for the new "air tight" fixtures when purchasing new recessed ceiling fixtures. They will greatly reduce air leakage (and heat loss) through the ceiling.

Where to buy efficient light bulbs:

- Check at discount retail department stores, home improvement centers and hardware stores – let the managers know you're interested. There's nothing like demand to stimulate supply.
- Most commercial lighting supply houses, which supply lamps to businesses, will also sell to the public. Look in the yellow pages under "Lighting."
- Check with your local electric utility. Many either sell efficient light products or offer rebates as part of a conservation program that can delay or eliminate the need for new power plants.

Where to find more information:

- *Planning and Designing Lighting*, Edward Effron (1986)

An excellent book for anyone interested in setting up an efficient, attractive lighting system. Easy to understand with excellent photographs and illustrations.

- Basic how-to guides from Time/Life, Ortho or Sunset

These guides provide a good explanation of basic lighting concepts and selection of light sources.

- For individual help with lighting design, check with a lighting specialty store where they often have trained designers on staff – although be aware that energy efficiency may not be their top priority. Look under "Lighting Consultants" in the yellow pages.

These manufacturers have design information for consumers available on their web pages.

http://www.sylvania.com/
http://www.lighting.philips.com/

The Lighting Resource
P.O. Box 48345
Minneapolis, MN 55448-0345
http://www.lightresource.com/

Lighting Research Center
School of Architecture,
Rensselaer Polytechnic Institute
Troy, NY 12180
http://www.lrc.rpi.edu/

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Wood Heat

Minnesota Department of Commerce Energy Information Center

Wood is a widely used heating fuel: approximately a third of all Minnesota homes use wood at least occasionally to provide space heat. Wood can be an effective and economical source of heat, provided all necessary steps are taken to ensure efficiency, environmental health, and fire safety.

The purpose of this guide is to describe the necessary steps to achieve an efficient and safe wood fire. They start with the basic decision on the type of equipment to use, followed by instructions on proper installation, maintenance, and operation. The guide deals only with stoves and does not address wood burning furnaces, boilers, or open fireplaces.

A few words of caution: If you are considering becoming a first-time user of a wood stove, you should examine your own expectations of what a wood stove will provide. Although the new stoves on the market are much improved over previous models, they are not a substitute for a central heating furnace.

Types of wood stoves

A variety of wood stoves are in use today, but anyone who wants to heat efficiently and cleanly with wood will want a model that meets Environmental Protection Agency (EPA) standards. Most new stoves sold today must meet these efficiency and emission standards (some small manufacturers are not required to meet EPA standards), which represent considerable progress over the standards of stoves sold just a little more than a decade ago. The certified wood stoves of today have efficiencies ranging from 63 to 78 percent, compared to 40 to 50 percent for stoves sold in the 1970s and '80s. They also emit less than one-tenth the amount of smoke.

Three types of residential stoves meet these standards: catalytic, high tech non-catalytic, and pellet burners.

Catalytic stoves. These stoves use a catalytic combustor that operates on the same principle as the catalytic converter in your car. In a conventional wood stove, as much as 30 percent of the fuel can go up the chimney as unburned fuel when the unit operates at moderate temperatures – between 500º and 600ªF. For complete combustion, the conventional stove must burn at nearly 1,000°F. The catalytic stove, in contrast, obtains complete combustion at approximately 500°F. This increased combustion gives more "mileage" from the fuel and produces less air pollution, particularly on mild autumn and spring days when the chimney's natural draft is reduced and the building heat loss is low.

In operating a catalytic stove, make sure that the combustor is ignited. The stove should burn moderately for 10 to 30 minutes until it reaches the 500° required for ignition. It is best to check the temperature using a catalyst temperature probe (see Figure 1), which may come with the stove or be purchased for $15 to $45. Maintain the temperature within 1,200° to 1,400°F; significant damage will occur above 1,800°F.

Only untreated, well seasoned wood should be used and the combustor should never be scraped, jarred, or blown out with an air compressor. If

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Combustion Air

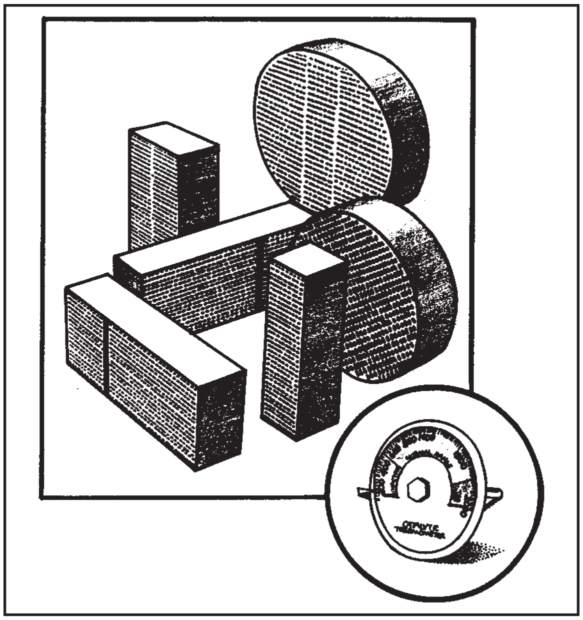


Figure 1
Catalytic combustors come in a variety of shapes and sizes; bottom right is a typical temperature probe with an operating range of 500° to 1800°F.

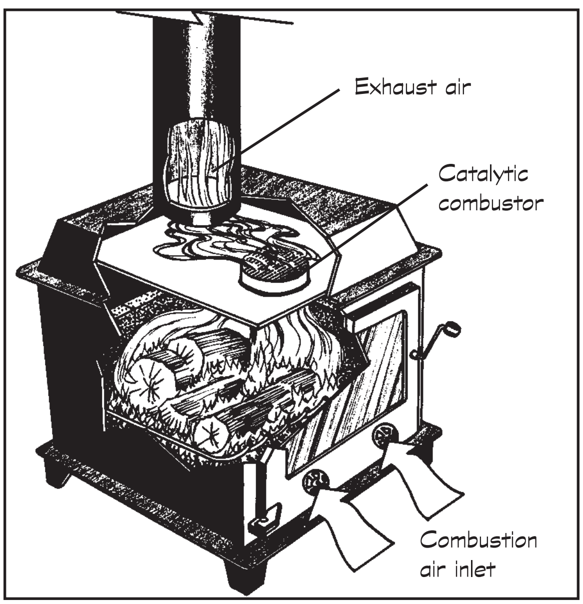


Figure 2
Catalytic stoves are highly efficient and allow the most user control.

these guidelines are followed, the combustor should be effective for up to 12,000 hours (about three to six years). If increased smoke comes out of the chimney at low burning temperatures, or if the unit has difficulty maintaining a temperature of 900 to 1,000°, the combustor probably needs replacing. The EPA requires that combustors should be easy to inspect and replace and that they be guaranteed for at least two years. The cost of replacing a combustor ranges from $60 to $200, but in a two year period, the combustor should save more than that in fuel savings.

It is possible to retrofit a stove with a catalytic combustor, but the add-on devices are usually only about half as effective as a new unit with a built-in combustor.

A well designed catalytic stove (Figure 2) costs from $900 to $1,700 and offers the following benefits:

- Produces 80 to 90 percent less pollution at low to moderate temperatures.
- Provides combustion efficiency of at least 72 percent when the stove is new.
- Uses 25 to 30 percent less firewood.
- Requires less frequent chimney cleaning because the clean burn produces less creosote.
- Provides increased safety because less creosote means less chance of chimney fire.
- Allows the user to throttle down the fire manually.

High tech non-catalytic wood stoves. Many EPA certified stoves achieve high rates of combustion without a catalytic combustor. Non-catalytic stoves (Figure 3) are slightly less efficient, with ratings from 63 to 75 percent, and they often require more frequent refueling. They offer advantages, however: a wider choice of fuel can be used and there is no need to replace a catalytic combustor. A “non-cat” stove costs from $500 to $2,000, depending on size and style, and offers the following features:

- Preheats incoming air to keep combustion temperatures higher for more complete combustion.
- Stationary baffles direct gases back to the combustion zone for more complete burning.

- Pre-heats secondary air to reignite gases and reduce fuel loss up the chimney.
- Stationary air inlets ensure adequate air for combustion.
- Small fireboxes lined with firebricks maintain high temperatures in the combustion zone.

Pellet stoves. Some EPA certified stoves burn fuel pellets manufactured from wood or other biomass. With a pellet stove (Figure 4), you load batches of fuel into a hopper. A motorized auger, controlled by a dial or thermostat, then moves the pellets into the stove as needed. A small fan controls air flow in the combustion process.

When buying wood pellets, pay attention to the ash content, making sure the particular ash level is compatible with your stove. Most stove dealers should be able to give you information on where to obtain the appropriate pellets.

Pellet stoves, like the other stove types, have advantages and disadvantages. The fans and augers consume only about 150 watts of electricity, but they can't provide heat during power outages. Fuel must be obtained from a dealer, rather than a local wood lot (pellet prices, however, have remained fairly stable). Pellet stoves are more expensive than most wood stoves, costing from $1,500 to $2,000, but they don't require expensive chimney systems. They also have controlled air-to-fuel ratios that allow them to achieve nearly complete combustion, and their excellent heat transfer ranks them among the lowest in smoke emissions and highest in efficiency.

Basically, pellet stoves are a good choice if you do not have a reliable wood supply or if you want to avoid installing a more expensive chimney system.

Selecting a wood stove

In deciding which of the three types of stove is right for you, consider the initial cost, the operating cost (including fuel and electricity for fans), availability of fuel, appearance, and insurance company requirements. Talk with your instance agent before buying a stove. Some insurance companies will not provide coverage for a home that is heated by a wood stove. Others will, but some charge very high rates. You may need to have your installation inspected by the insurance company before your

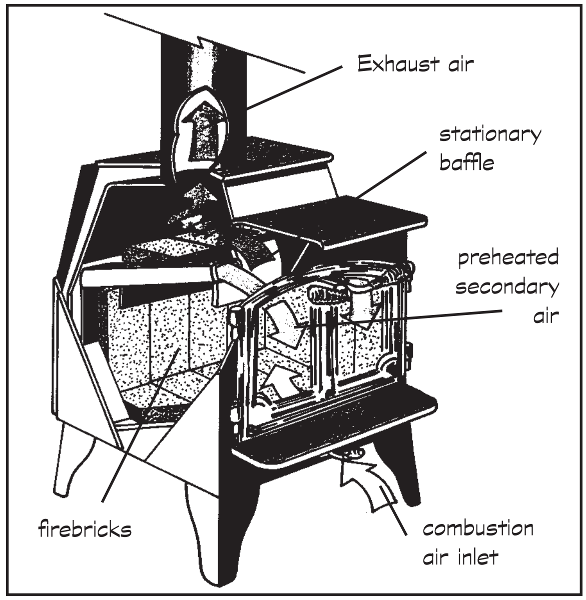


Figure 3
High tech non-catalytic stoves are slightly less efficient than catalytic stoves, but are also less expensive and will adapt to a wider choice of fuel.

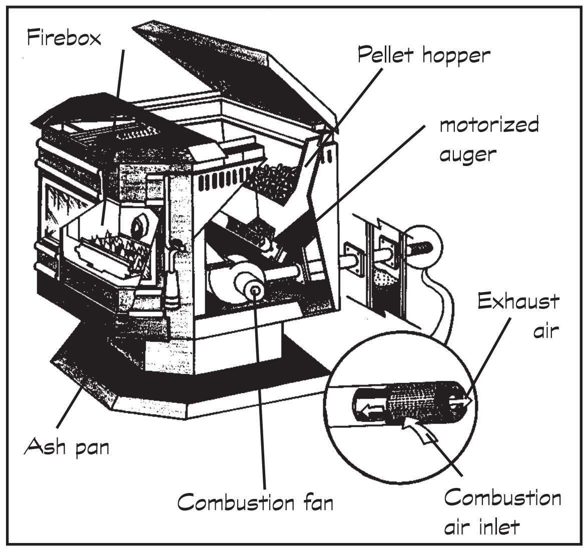


Figure 4
In pellet stoves, a fan pulls air into the firebox through a two-part pipe system that also acts as a heat exchanger as the outgoing exhaust air warms the incoming air for combustion.

Tip

Wood stoves must be installed to meet fire protection standards.

Before buying and installing a wood stove

- Check first with your insurance agent to make sure you can continue to have house insurance and what the rates will be.
- Next, apply for a permit from your local building inspection department. The Minnesota Uniform Fire Code requires solid fuel burning appliances to be listed and installed in accordance with the terms of their listing. If your appliance is not listed, it can be approved provided it is installed in accordance with the Minnesota Fire Code. Your local building inspector can provide you with the specific requirements of the Fire Code.
- If you reside in rural Minnesota or in a community that does not have a building inspector, you can discuss the specific installation procedures, clearances from combustible materials, and other requirements of the Minnesota Fire Code by consulting with your insurance company or local fire department or by writing the State Fire Marshal Division, Minnesota Department of Public Safety, 444 Cedar Street, Suite 100M, St. Paul,, MN 55101-2156.

coverage begins. Before buying a stove, you should also check with your local municipality regarding required permits and inspections.

Emissions, efficiency and safety certification. Make sure the stove you are buying meets efficiency, emissions and safety standards. As previously noted, all new stoves from major manufacturers sold today must meet EPA efficiency and emissions standards. The stoves carry both a permanent and temporary label. The temporary label compares the stove's average performance with the emissions standards, allowing you to compare one stove to another. The permanent label (Figure 5) shows emissions and efficiency levels for a range of heat output. Use this information to select the proper size unit for the space you will be heating (see section, "Sizing a stove," below).

The Minnesota Uniform Fire Code requires solid fuel burning appliances to be listed and installed in accordance with the terms of their listing. Unlisted appliances can be approved by your local authority, but they must be installed in accordance with standards of the National Fire Protection Association (NFPA) Standard 221.

A listed stove has been tested to meet standards established by organizations such as the International Council of Building Officials (ICBO) and Underwriters Laboratory (UL). Safety labels must be permanently affixed to a "listed" stove. The label must state the name of the laboratory that conducted the safety test, the test standards that were applied, and basic installation requirements for the stove. If there is no label permanently attached, the stove has not been tested and is not listed for safety.

Features promoting efficiency, clean-burning. Whatever type of stove you buy, look for features that promote clean, efficient burning, such as:

- Air supply ducts that allow incoming air to be preheated and directed into the active flames, increasing combustion efficiency.
- Baffle plates designed to regulate the flow within the stove, directing incompletely burned gases to the active fire, resulting in better combustion efficiency.
- Firebox insulation sufficient to maintain an average firebox temperature slightly above the 1,000°F. required for clean combustion and to protect the metal surfaces of the firebox. Without firebox insulation, the fire is continuously cooled as the heat escapes to the room air surrounding the stove.
- Secondary air supply that allows for the combustion of unburned gases that would otherwise escape up the chimney and pollute the air.

Other design features. These design features do not affect efficiency of the stove, but should be kept in mind for your own convenience.

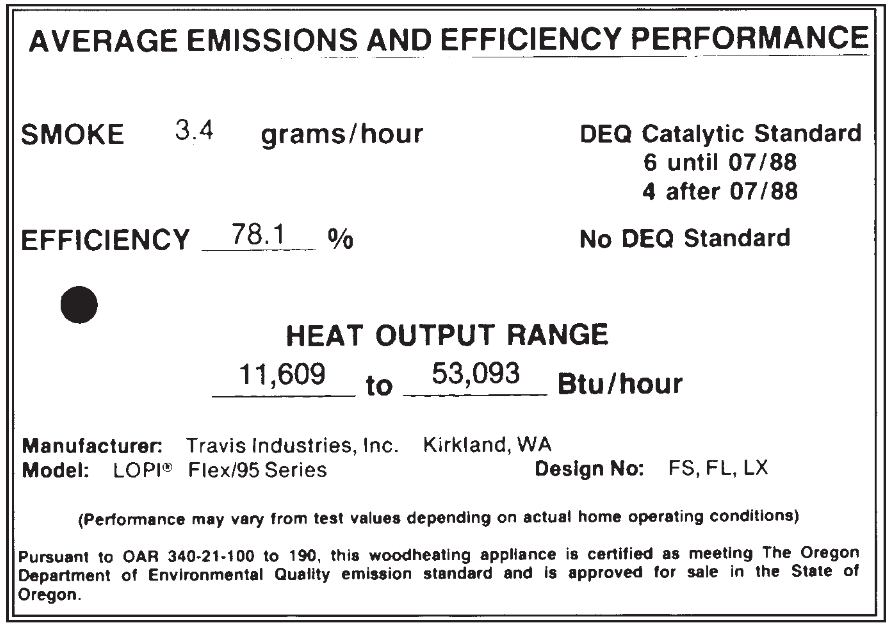
- An ash pan eases removal of ashes.

- A circulating stove, which uses fans to circulate warm air, is safer for households with children, since its hot stove surfaces are covered by an outer jacket. A radiant stove has no outer jacket and heats principally by infrared radiation (heat moving by long wavelength from one surface to another), considered by some to be a more comfortable form of heating.
- Door location and size determine how easily the wood fuel can be loaded.
- Firebox size determines how big the wood pieces can be.
- A cast iron stove versus plate steel is largely a matter of preference. Cast iron may crack, plate steel may warp, and both may corrode, but neither has been proven more efficient than the other. Top quality tight-fitting construction, rather than material, is the key to a good stove.
- There are two types of automatic damper controls – one type completely opens or shuts the damper and the other makes gradual adjustments. Each has its own characteristics, but average room temperatures are the same for comparable systems.
- Liners, either firebrick or steel, extend the life of the firebox and are much less expensive to replace than the stove itself. They also provide thermal mass to store heat.

Sizing a stove. The most common mistake in sizing a stove is selecting a stove that is too large for the area to be heated. The primary factors involved in sizing a stove are:

- Volume of open area to be heated.
- Your home's insulation and weatherization level.
- Rate of infiltration.
- Average outside temperature during the heating season.
- Location of stove within the building.
- Volume and placement of combustion air/draft air inlet.

Call the Energy Information Center and talk to one of our energy specialists for advice on the proper size stove. Then contact a wood dealer or contractor with experience in your area, and with your style of home.


AVERAGE EMISSIONS AND EFFICIENCY PERFORMANCE

SMOKE 3.4 grams/hour — DEQ Catalytic Standard 6 until 07/88, 4 after 07/88

EFFICIENCY 78.1 % — No DEQ Standard

HEAT OUTPUT RANGE
11,609 to 53,093 Btu/hour

Manufacturer: Travis Industries, Inc. Kirkland, WA
Model: LOPI® Flex/95 Series — Design No: FS, FL, LX

(Performance may vary from test values depending on actual home operating conditions)

Pursuant to OAR 340-21-100 to 190, this woodheating appliance is certified as meeting The Oregon Department of Environmental Quality emission standard and is approved for sale in the State of Oregon.

Figure 5
A permanent label relating emissions and efficiency to heat output is required by the EPA and helps in sizing the stove.

Installing a wood stove

Proper installation of a wood stove is necessary for clean and efficient operation and – even more important – for safety. Improperly installed wood stoves and chimneys are the major cause of house fires. As previously noted, Minnesota has a statewide fire code requiring wood stoves to be installed according to certain standards. *Always follow manufacturer's instructions, paying particular attention to clearance from combustible surfaces. It is advisable to have professional help in installing a stove.*

Location. Your stove should be located in a frequently used area such as the living room or family room. When you have decided on a location, inspect the structural support under the floor on which the stove will be placed to make sure it is adequate.

The best place for a stove is in the center of the room, where it can radiate heat in all directions. The worst place to put a stove is in a closet or alcove. Stoves are often placed in the middle of

Tip

Cheating on clearances means a certainty of a fire!

an outside wall and vented straight up through the roof. In any case, installation requires proper clearance between stove system surfaces and their surroundings to keep your home safe from fire. Remember, heat transfer from the walls of the stovepipe and chimney, as well as from the stove, must be considered.

Clearances from combustible materials. Constant exposure to heat lowers the temperature at which a material will begin to burn. A joist or rafter too close to the chimney walls, or a wall stud too close to the stove and its stovepipe, will overheat and ignite. *Clearances are specified by safety codes to prevent overheating of combustible materials by keeping them at a safe distance. Cheating on these clearances means a certainty of a fire!*

Each manufacturer of listed stoves is required to specify minimum clearances. These clearances vary, depending on the construction of the stove. When installing your wood heating system, you must follow the manufacturer's instructions. If you install a stove for which there are no instructions, you should observe the clearances listed in the section on Clearances later in this guide.

A noncombustible material is defined as that which will not ignite or burn when subjected to flame or intense heat for long periods of time. Steel, iron, brick, tile, concrete, slate, and glass are noncombustible.

All walls containing wood framing are combustible, including plaster and sheetrock walls on wood lath or wood studs. Nearly every wall and ceiling in residential buildings contains wood. If you are unsure about your home, assume that the wall or ceiling is combustible and maintain proper clearance.

A floor is considered noncombustible if it is concrete, slab-on-grade design, or solid concrete with steel or concrete–but not wood–supports. An existing masonry hearth extension is noncombustible if no wood forms have been left in place below it, and if stove placement allows at least 18 inches of hearth extension in front of the loading door.

All wood floors, carpets and synthetic materials are considered combustible and must be protected in an approved manner. Other combustible materials include furniture, draperies and newspaper.

All stoves and stovepipes require a minimum clearance to unprotected combustibles on top and on all sides of the wood stove.

No clearance is needed for stoves or stovepipes to noncombustible walls (i.e., concrete walls or dirt floors). It is a good practice, however, to allow six inches or more for good air circulation and heat dissipation.

Protective or clearance reduction systems. Installing a clearance reduction system will reduce heat transferred to the combustible surface, allowing specific clearances to be lowered. See the section on Clearances later in this guide.

A variety of prefabricated clearance reduction systems are available through wood stove and fireplace dealers. Always look for the safety listing and make sure the system is designed to be used with a wood stove. The manufacturers of these tested and listed accessories provide specific installation instructions that must be followed.

Floor protection. *All combustible floors must be protected.* The only base on which a stove can be installed without special protection is a noncombustible floor or properly built hearth extension. Manufacturers of listed stoves usually specify the type of material required for floor protection and these materials should be used. If the manufacturer does not specify a material, you may purchase one or more of the safety tested and listed prefabricated stove boards on the market.

Chimneys and stovepipes

A chimney is a critical part of your wood heating system. It carriers smoke out of the house, and creates the suction or draft necessary to draw air to the fire. A well designed chimney allows the stove to operate cleanly, producing a minimum amount of smoke and creosote. Chimneys used with wood stoves must meet "all fuel" standards, also called "Class A."

The chimney connector or vent connector is commonly known as the stovepipe. It connects the stove to the chimney. A stovepipe has a single metal wall and may not pass through a well, ceiling, attic, closet, or any concealed area.

Studies show that most house fires related to wood heaters originate around the chimney or

Smoke and carbon monoxide detectors

Smoke detectors should be installed on every level of your home. If you burn wood, it is even more important to have working smoke detectors. Fires can smolder for hours, long after flames have gone out.

The majority (75 percent) of fatal fires occur in residences. Most fatal fires occur between midnight and 6 a.m., when people are asleep. Smoke detectors are designed as an early warning device to awaken sleeping residents.

Test all smoke detectors monthly and change batteries once a year. Make sure you and your family have an early warning that allows you time to escape in the event of a fire.

A backdrafting stove can be as lethal as an actual fire. The Energy Information Center recommends installing a CO detector alarm. Make sure it has a UL listing.

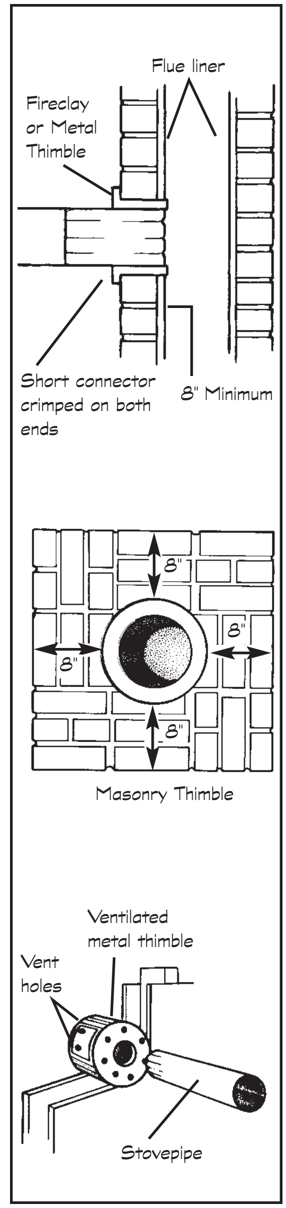
stovepipe. According to the U.S. consumer Product Safety Commission, house fires involving chimneys are caused primarily by creosote buildup in the chimney (creosote is soot and tar produced as a by-product of wood burning), metal chimneys too close to combustibles, chimney failure, improper construction or deterioration of a masonry chimney, and improper installation of a chimney connector (stovepipe). *Before building or installing a chimney and stovepipe, therefore, it is very important to contact the fire marshal's office and the local building code officials for information on making your system safe.*

Chimney height is critical to creating proper draft and meeting fire codes. The chimney should extend at least three feet above the point where it exits the roof, and should be a minimum of two feet higher than any part of the roof within ten feet. (See The 3-2-10 rule.)

For safety reasons, the stovepipe should be as short as possible, but installations with five feet or so of pipe are acceptable. Keep in mind that the most trouble-free system will have few, if any, horizontal pipe sections and elbows. A vertical stovepipe gives the best possible draft and allows creosote and soot to fall back into the stove to be burned. Long runs of stovepipe should be avoided because they inevitably fill up with soot, ash, and creosote.

Thimbles. Use a metal or fire clay thimble when passing a stovepipe through noncombustible walls. The thimble should be permanently cemented into the masonry chimney and extend through the chimney wall to the inner face or liner, but not beyond. Push the short section of stovepipe, crimped on both ends, into the thimble and secure it with high temperature sealant. The stovepipe should extend as far as possible into the thimble, but should not stick out into the chimney.

If you must vent through a combustible interior or exterior wall, contact the fire marshal for instructions. A stovepipe may never pass through a ceiling, closet, or concealed area. For these situations a "Class A" chimney is required. Once the stovepipe connects to the chimney, it must remain a chimney from that point on. No further use of stovepipe is allowed.



Thimbles must be used to connect the stovepipe to the chimney.

Tip

All chimneys need to be regularly inspected for deterioration and creosote buildup

Masonry or metal chimney. Whether to have a metal or masonry chimney depends on a number of factors: both types have advantages and disadvantages.

Metal chimneys are often less expensive than masonry chimneys and are more adaptable to installation in existing houses. *(Some insurance companies, however, will not approve coverage for homes with a metal chimney; be sure to check with your insurance company before installing a metal chimney.)* Most masonry chimneys require the work of an experienced mason and are usually built at the same time as the house.

A chimney cap is often added to keep out rain. On masonry chimneys, a flat plate of steel or concrete is most often used, but more stylish ceramic and metal caps are available. Caps for safety tested and listed manufactured chimneys are also available.

Masonry chimneys are very durable, and some homeowners consider them more attractive than prefabricated chimneys. In addition, massive interior masonry chimneys will store heat longer and continue to release this heat to the room long after the wood fire has subsided.

Masonry chimneys also have disadvantages. They are expensive to build and more difficult to inspect and maintain than prefabricated chimneys. In addition, masonry chimneys are often built on an exterior wall, reducing heating efficiency. This exposure to cold outdoor temperatures leads to greater heat loss and higher accumulations of creosote deposits.

Whether you have a masonry chimney built or plan to use an existing one, safety should be your prime consideration. A masonry chimney is a very heavy structure that must be able to withstand many years of use, including occasional chimney fires in which temperatures may reach 2,700°F.

Safety do's and don'ts when connecting a wood stove to a masonry chimney:

- Make sure the stove will have enough air for combustion and proper draft for that size chimney.
- Check the general condition of an existing chimney. Look for loose bricks and cracks in the mortar that might allow creosote to leak out or sparks to escape and ignite creosote or dry structural wood. Have a competent mason do any needed repairs.
- Many older homes have chimneys that are in good structural shape but do not meet "all fuel" or "Class A" requirements. A typical example is a chimney constructed of four-inch brick without a fire clay liner. These chimneys can be made safe by lining them with safety listed liners.
- Each wood burning appliance must have its own flue (a fireplace is considered an appliance). If you have more than one fireplace, check the chimney to make sure that a flue exists for each appliance.
- Frequently in older homes an existing masonry chimney may have served more than one appliance in various rooms. It is critical to locate and seal these unused entry ports or breachings. Unused breachings are often covered with a thin metal "pie plate" cover. They may be hidden by paneling or plaster, especially if the house has been remodeled. Unused breachings should be sealed using masonry and fire clay mortar to make the former entry port as sound as the rest of the chimney.

Chimney inspection and cleaning. *All chimneys require regular inspection for deterioration and creosote buildup.* A correctly built chimney can settle and require repair within time – a poorly built chimney is dangerous from the start. The chimney should be inspected and cleaned at least once a year, as often as biweekly if you use your wood stove daily. Remember that a cleanout opening is required and provides a convenient way to remove creosote after a cleaning. The opening should be more than two feet below the stovepipe entry port, should be made of ferrous metal frame, and must have a door designed to remain airtight when the stove is in use. Also, disassemble the smokepipe and inspect it.

Clean the chimney when creosote deposits are one-quarter inch thick. Inspect the flue at both the stove end and chimney top. Remember that cooler surfaces will have the thickest creosote deposits (these are usually near the top).

You can have a professional clean your chimney or you may choose to clean it yourself. Wear a

The 3-2-10 Rule

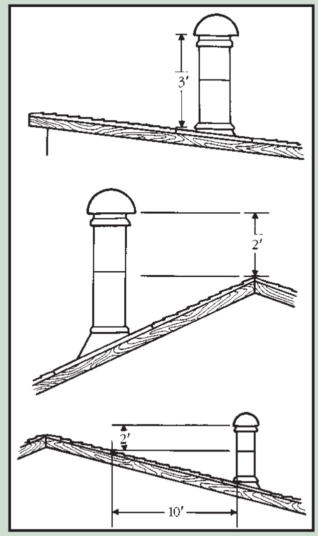
Chimney height is critical to creating proper draft. The chimney must extend at least three feet up from the roof and be at least two feet higher than any part of the roof within ten feet, measured horizontally. Measurements are made from the high side of the roof to the top of the chimney wall.

If your chimney is 10 feet or more from the roof ridge, you may use Table 1 directly. If the ridge is closer than ten feet, calculate the proper height by using the numbers from Table 1 in the following formula: Roof slope x Distance to ridge + 2 feet = Required height above the roof.

For example, a chimney on a 5/12-slope roof located 6 feet from the ridge requires: (5/12 x 6 ft.) + 2 feet = 4 feet, 6 inches above roof.

Table 1
Minimum Chimney Heights

Roof slope*	Height above the roof ridge 10 feet or more from chimney
Flat	3'
1/12	3'
2/12	3'8"
3/12	4'6"
4/12	5'4"
5/12	6"2"
6/12	7'
7/12	7'10"
8/12	8'8"
10/12	10'4"
12/12	12'



* Roof slopes are given in feet of rise per 12 feet of run. A 6.12 slope rises 6 feet per 12 feet of horizontal run.

protective mask and goggles and gloves and use a quality steel-bristle brush. You'll also need to clean the inside of the stove and stovepipe. If you suspect leaks or cracks in your stove system, call in a professional to perform a leak test. If any leaks are found, have them repaired immediately.

Chimney fires. Chimney fires occur when creosote on the inside of a chimney wall burns. Chimney fires most likely occur during a very hot fire, as when cardboard is burned or when normal wood is burned at a very high rate. A crackling sound is often the first sign of the over-firing of a stove that precedes a chimney fire. As intensity grows, the stovepipe may shake violently, air will be forcefully drawn in through the stove, and the stovepipe will glow red hot. Another symptom of overfiring a stove is "back-puffing" – small puffs of smoke come out of the combustion chamber making a sound similar to a heavily muffled backfire from a car. A tall plume of flame and sparks will rise from the top of uncapped chimneys.

When a chimney fire starts:

- Close the dampers. This limits the air supply.
- Call the fire department immediately.
- Wet down the roof and other outside combustibles to prevent fires started by shooting sparks and flames.
- Keep a close watch on all surfaces near the chimney.
- Have the chimney inspected before using it again. Cracks or openings caused by the fire may allow creosote to leak out. The next chimney fire may include your attic or interior walls near the chimney.

Combustion air

Minnesota building codes require an outdoor air inlet to ensure adequate air for combustion. The size of the inlet required depends on a number of variables, such as type and height of chimney and heating size of the stove. Check with your building code officials. Without an outdoor air supply, your stove will take combustion air from the room, creating the potential for dangerous back-drafting of noxious gases and smoke into the house. With inadequate combustion air, your central furnace or water heater may backdraft toxic gases, even if the fireplace or stove appears to work properly.

Some wood stoves draw outdoor air directly into the stove, ensuring an adequate combustion air supply and reducing unwanted infiltration. If your stove does not have this feature, call the Energy Information Center and ask for a copy of "Combustion Air." This guide provides suggestions on how to install an air inlet. For a new home built to meet energy codes, an air inlet is absolutely necessary.

Fuel

The kind of wood you burn affects the amount of heat you receive. Density and moisture content of the wood affect combustion. Dense species, such as white oak, that are well seasoned or dried have higher energy content per volume. Burning "green" wood, which contains as much as 50 percent water, consumes a large amount of heat energy simply to dry the wood prior to combustion. "Dry" wood has 15 to 20 percent moisture by volume.

Wood fuel is measured in cords, with one standard cord equaling 128 cubic feet (4x4x8), assuming the wood is cut into four-foot lengths and ranked. If the sale is of sawed wood, a cord is 100 cubic feet when ranked, or 160 cubic feet when thrown irregularly or loosely into a truck. If the wood is sawed and split, a cord is 120 cubic feet when ranked and 175 cubic feet when thrown loosely into a truck.

Sometimes wood is measured in "face cords," or by other definitions often smaller than a standard cord, so make sure you know what you are buying. You should get a bill of sale with clearly defined volumes.

What not to burn:

- Household garbage can produce noxious and corrosive gases and can foul a catalytic combustor.
- Newspaper and magazines cannot be used in catalytic stoves because the lead and other metals in the ink can foul the combustor.
- Plastics and junk mail can cause lethal fumes.
- Treated or painted wood can produce very toxic and sometimes explosive gases.

Operating a stove properly

To ensure that you operate your stove efficiently and safely, observe the following guidelines.

- Start the fire with dry kindling and with air inlets and dampers wide open for maximum air.
- Add two or three pieces of dry wood, keeping air inlets and dampers open.
- *Never light or rekindle a stove fire with kerosene, gasoline, or charcoal lighter fluid – the result can be fatal.*
- In 15 or 20 minutes, when the fire is burning well, adjust air inlets and dampers to control the speed of burn.
- Add only one or two pieces of firewood at a time and provide more air each time fuel is added.
- Determine if you have the proper air supply by checking what's coming out of the chimney – dark smoke indicates that more air is needed. A note of caution: most manufacturers of cast iron stoves recommend keeping the first fires small to break in new stoves gradually. New stoves always smoke on start-up as the paint and sealants are heated. Be prepared to open windows and doors for ventilation.
- Always keep a fire extinguisher and a bucket of sand nearby. Use water on wood stove fires only in extreme emergencies: the water turns to steam, scatters hot ash everywhere, and can crack cast iron stove parts and damage chimneys.
- When refueling, open the damper and air inlet fully a minute before opening and loading. For airtight stoves, this is especially important because a sudden rush of air into the chamber can trigger a small explosion. Escaping gases can seriously burn anyone standing nearby. All openings in operating stoves should be opened slowly, and the operator's face should be kept well back from the stove for a few minutes after opening.
- When refueling a non-catalytic stove, allow the fire to die down some before adding fuel. For effi-

Creosote

The perfect fire would result in complete combustion, leaving only water and carbon dioxide as by-products. In reality, combustion is never complete. Hot unburned gases, solid particles, and tar-like liquids go up the flue as smoke. As these substances contact the cooler flue surface, they condense. When the water evaporates, it leaves behind a tar called creosote, which builds up fire after fire into a crusty black layer.

Creosote is the enemy of wood stove users and should be feared because it causes chimney fires. It is highly flammable. Large deposits can block the flue and make the stove smoke.

The amount of creosote formed in the flue depends upon a number of factors. The smokier the fire, the bigger the creosote problem. When the fire is hot enough, creosote burns along with the other organic compounds in the wood. A good hot fire is a cleaner fire. It is easier to make a small fire hot. Don't overload the stove; it will smoke.

High moisture wood leads to higher creosote formation because the water vapor inhibits combustion, making the fire cooler and smokier. The more smoke, the more creosote. The cooler temperatures result in more condensation on the flue walls.

With any type of wood, smoke production is greatest when fresh wood is added or when air supply is turned low. At these times, combustion efficiency is lowered, and heavier smoking results.

Increased levels of creosote are associated with soft woods because of their high resin contents. Dry hardwoods have a reputation of generating the least amount of creosote. Seasoned softwood fires will not produce large amounts of creosote.

To cut down on creosote deposits:

- Burn well-seasoned hardwood.
- Keep a brisk burning small fire and maintain a good draft.
- Add small loads of wood frequently rather than fewer large loads.
- Don't ever add a full charge of green wood—this will generate large amounts of creosote.
- A wood stove fire should not be allowed to smolder all night long, with exception of a catalytic stove fire. For the catalytic stove, add the last charge of wood an hour before retiring, reducing the wood to cleaner burning charcoal.
- Minimize the length of stovepipe connecting the stove to the chimney.
- The only way to remove creosote safely is by a traditional chimney cleaning that includes scraping the creosote from the inside of the flue.

ciency and safety you are better off burning many small hot fires rather than one slow-burning fire.

- Don't overfire the stove: red hot stovepipes and overheated fuels will warp and damage the metal and can cause chimney fires.
- Watch out for handles and surfaces too hot to touch with bare hands.
- Before going to bed or leaving the house, always check to see that the stovepipe damper is open, the stove door securely fastened, and combustibles a safe distance from the stove.
- Ashes that seem cool may contain hot embers, so always place ashes in a metal container with a tight fitting lid. (Leave an inch or more of ashes to protect the bottom of the firebox.) Place the container on a noncombustible floor or on the ground, 15 feet away from combustible materials or buildings until final disposal. Embers/ashes can remain hot for up to 48 hours.
- Do not put green or wet wood on top of the stove to dry it. Such a practice is very dangerous. Do not, in fact, put anything on top of the stove unless it is absolutely fireproof.
- Do not store flammable liquids near the stove, especially in workshops, basements, and garages.
- If you suspect you have a problem, call the fire department as soon as possible. Don't take a chance with fire.

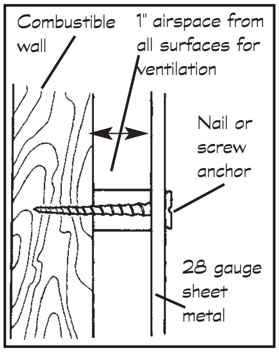


Diagram 1
Noncombustible spacers such as stacked washers, small pipe, tubing, or electrical conduit can be used to create the 1" air space. Masonry walls may be attached to combustible walls using wall ties. Do not use fasteners directly behind stovepipe or stove.

Clearances for Wood Stoves and Stovepipes

(Clearances listed in this section should be observed when manufacturer's installation instructions are not available. When manufacturer's instructions are available, compare the recommended clearances with those listed here. Using the larger clearance will provide a margin of safety.)

Unprotected floors, walls and ceilings. All stoves require a minimum 36-inch clearance to unprotected combustibles above and on all sides of the stove. A single wall stovepipe must have an 18-inch clearance to combustible walls and ceilings, measured at right angles to the pipe.

No clearance is needed to noncombustible walls (i.e., concrete). It is good practice, however, to allow six inches or more for good air circulation and dissipation of heat.

The only base on which a stove can be installed without special protection is a noncombustible floor or properly built hearth extension. Such a base should extend at least 18 inches on all sides of the stove.

Protected walls and ceilings. A wood stove and stovepipe may be placed closer than 18 inches to a combustible material if the material is protected in an approved manner with either a home-built or a prefabricated clearance reduction system.

The two most common types of home-built clearance reduction systems use 24 gauge sheet metal (galvanized steel, aluminum, copper) or 3-1/2-inch (4-inch nominal) thick masonry wall. Either of these materials must be spaced out one inch from the combustible surface; that is, they must be anchored to the combustible surface so that there is a one-inch air space between the sheet metal or masonry and the combustible material. (Diagram 1) With sheet metal, noncombustible spacers are used to maintain the one-inch air space. With a masonry wall, metal wall ties and furring strips, if needed, are used to anchor the brick to the wall. Do not place the spacers or wall ties directly behind the stove or stovepipe. The one-inch air space must be maintained around the entire perimeter of the clearance reduction system so that air flows freely and removes heat. This prevents the combustible surface from catching fire. Sheet metal or masonry attached to the wall without this air space offers no protection and cannot be considered a clearance reduction system.

A variety of prefabricated clearance reduction systems are available through wood stove and fireplace dealers. Always look for the safety listing and make sure the system is designed to be used with a good stove. The manufacturers of these tested and listed accessories provide specific installation instructions that must be followed.

Table 2 shows some clearances required using clearance reduction systems on walls and ceilings. These clearances are also depicted in Diagrams 2, 3, 4, and 5. (Masonry clearance reduction systems are used only on walls, not ceilings.)

The clearance reduction system must be centered behind or above the stovepipe to protect the wall or ceiling. The system should extend 36 inches past the stove in height and width, measured diagonally. If the stove is placed farther from the wall than the minimum distance required, the width and height of the clearance system can be determined by measuring from the side and top edge of the stove to the unprotected wall. This distance should be no less than 36 inches. The larger the distance between the stove or stovepipe and the wall, the smaller the clearance reduction system needs to be.

Some manufacturers may specify greater clearances. For a complete listing of clearances using clearance reduction systems, contact the fire marshal's office.

Protected floors. All combustible floors must be protected, and many types of materials are available for floor protection. Manufacturers of listed stoves usually specify the type of material required and, if available, these materials should be used. If the manufacturer does not specify a material, you may purchase one or more of the safety tested and listed prefabricated stove boards on the market.

Floor protection should extend 18 inches in front of the loading door to prevent damage to the floor from sparks, embers, ash or radiant heat. It should also extend 18 inches or more on the remaining sides of listed stoves, unless the manufacturer specifies a greater amount. (Diagram 6) An unlist-

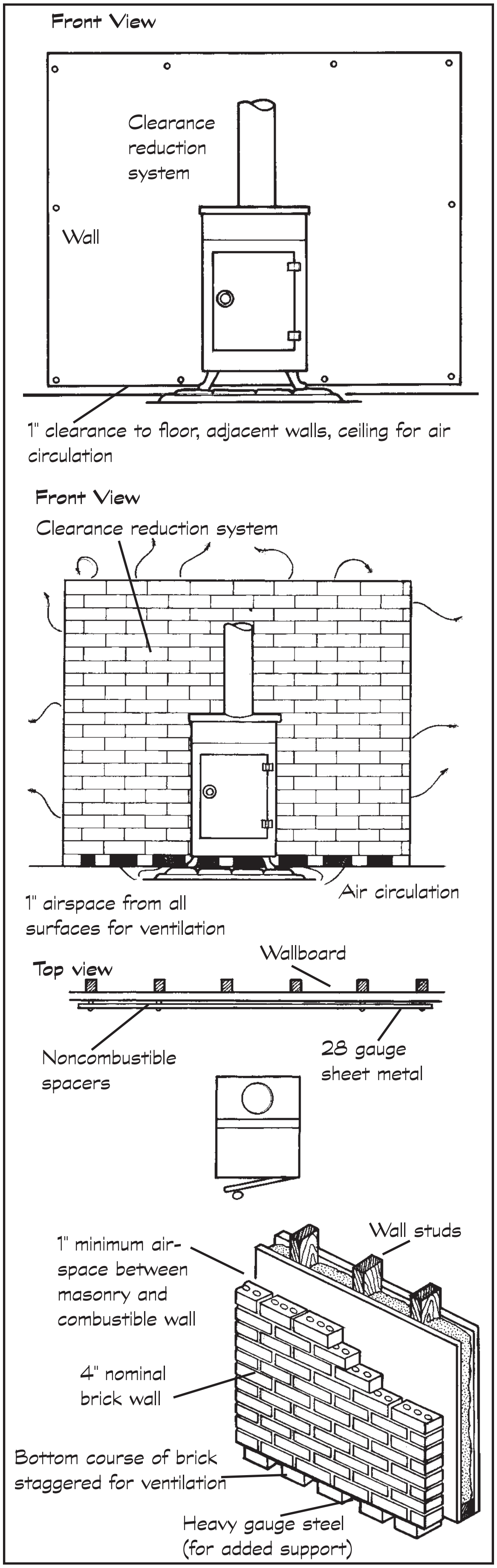


Diagram 2

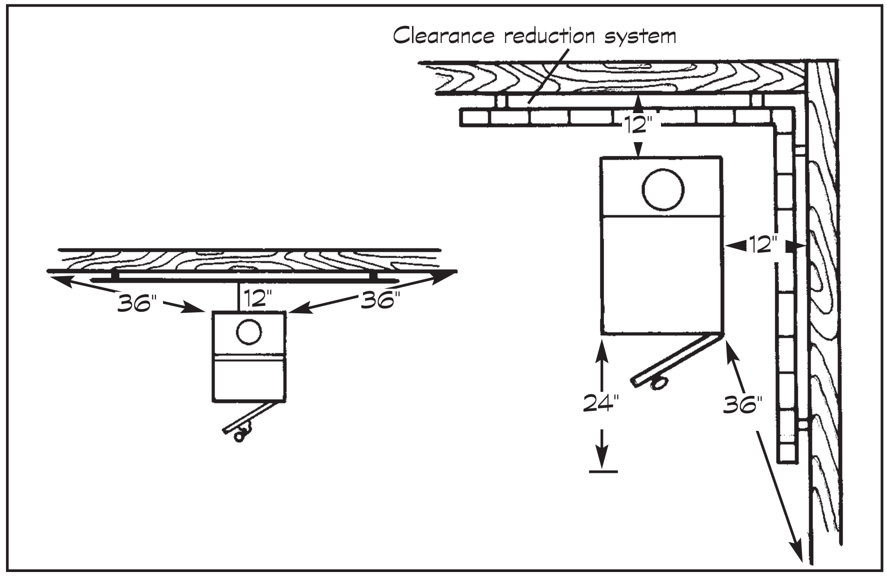


Diagram 3

A clearance reduction system using sheet metal or masonry can be used to safely shorten the distance from stove to combustibles.

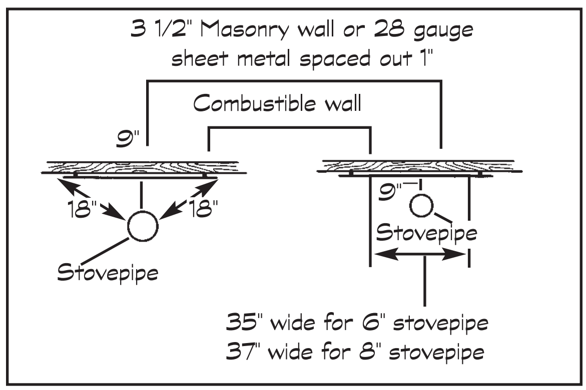


Diagram 4

For a 6-inch stovepipe, the protection must be 35 inches wide; 37 inches for an 8-inch stovepipe.

Diagram 5

Without protection, a stovepipe can be no closer than 18 inches to combustible ceilings and walls. By using a masonry wall or sheet metal, spaced out 1 inch from the combustible wall, the distance from stovepipe to combustible surfaces can be shortened to 9 inches.

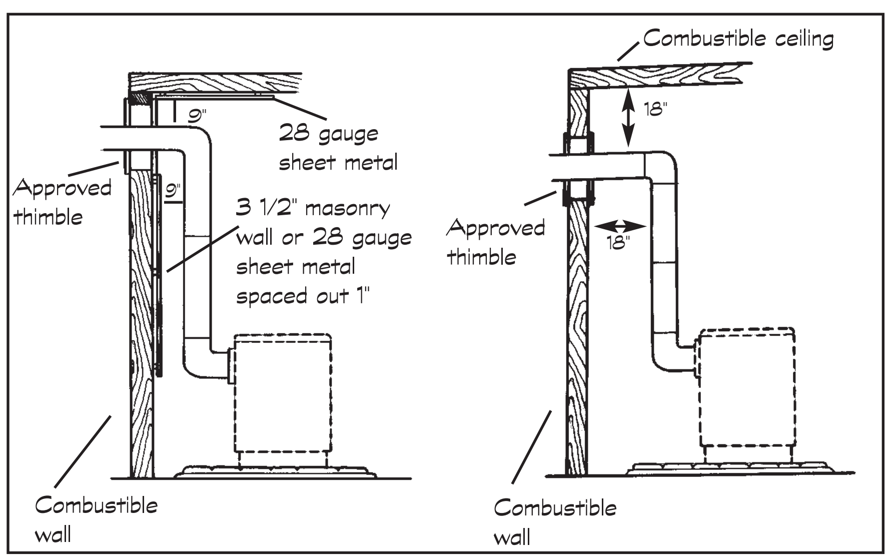


Table 2: Clearances Using Clearance Reduction Systems

TYPE OF PROTECTION	WOOD	STOVEPIPE
3-1/2" masonry wall spaced out 1"	12"	–
24 gauge sheet metal spaced out 1"	12"	9"
Prefabricated system	per manufacturer's specifications	

Notes:

1. These clearances are from the side of the stove or stovepipe to a parallel combustible surface.
2. Loading doors require at least a 24-inch clearance, even with clearance reduction systems or noncombustible surfaces, to allow room for loading the stove..
3. There must be at least a 36-inch clearance from the top of the stove to any unprotected combustible surface.
4. Use these clearances or those contained in the manufacturer's instructions, whichever is greater.
5. Masonry clearance reduction systems are used on walls, not ceilings.

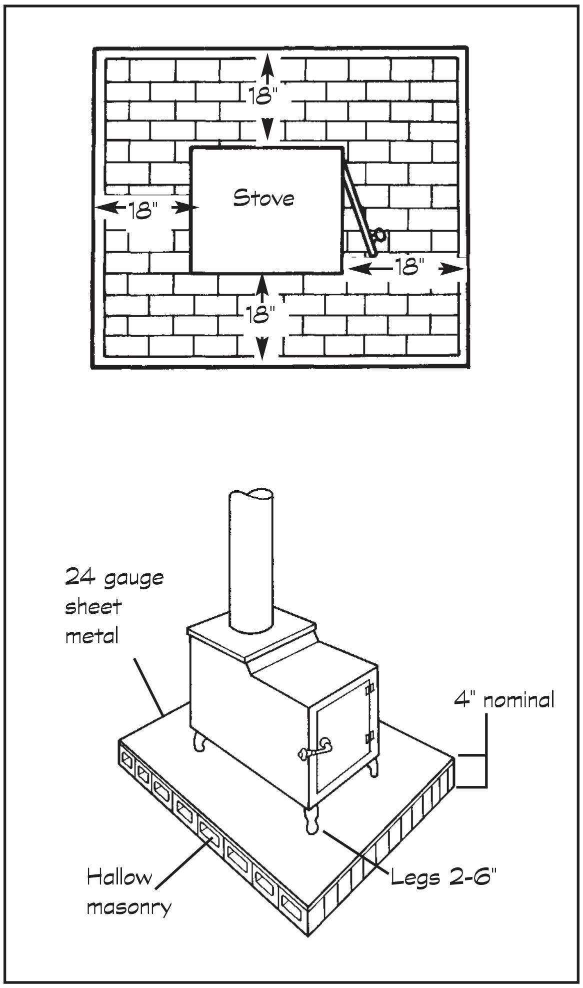


Diagram 6

Floor protection must extend 18 inches in all directions. For stoves with 2-6 inch legs, you must protect a combustible floor with 4-inch masonry arranged to allow air flow, and 24 gauge sheet metal.

ed stove requires 18 inches of floor protection on all sides, including the loading and ash doors.

If more than one safety listed prefabricated stove board is needed to meet the clearance requirements, the junction between the stove boards should be made using either a safety tested and listed stove board adapter or a strip of 24 gauge sheet metal four to six inches wide.

The type of floor protection recommended depends on stove leg length. Stoves with legs less than two inches in height must rest only on floor protection as specified by the manufacturer, safety tested and listed prefabricated stove boards, or a noncombustible floor.

If your stove has legs two inches or greater in height, you are also allowed to use a combination of sheet metal and masonry. The arrangement of sheet metal and masonry for floor protection depends upon the length of the stove legs:

- Stoves with legs two inches to six inches: Floor protection can consist of four-inch (nominal) hollow masonry laid to provide air circulation through the layer and covered with 24 gauge sheet metal. Another layer of masonry may be laid over the sheet metal for aesthetic appeal.
- Stoves with legs higher than six inches: Floor protection can consist of closely spaced masonry units of brick, concrete or stone that provide a thickness of not less than two inches. Such masonry must be covered by or placed over 24 gauge sheet metal.

If you use a combination of sheet metal and masonry for floor protection, be sure that each stove leg has a firm, solid footing.