Home Energy Guide

your source for keeping your home

comfortable, safe, durable,

and efficient

Minnesota Department of
Commerce
Division of Energy Resources

The Minnesota Department of Commerce Division of Energy Resources is working to move Minnesota toward a sustainable energy future, managing energy assistance funds and advocating in the public interest on energy utility rates and facility siting. We provide information and assistance on energy conservation, energy efficiency, and renewable energy options to residents, builders, utilities, non-profit organizations, and policy-makers on building improvements, financial assistance, renewable technologies, policy initiatives, and utility regulations. This consumer energy guide was produced, in part, with funding from the U.S. Department of Energy. Design, writing, illustrations, and editing by Division of Energy Resources staff.

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85 7th Place East, Suite 500

Saint Paul, MN 55101-2198

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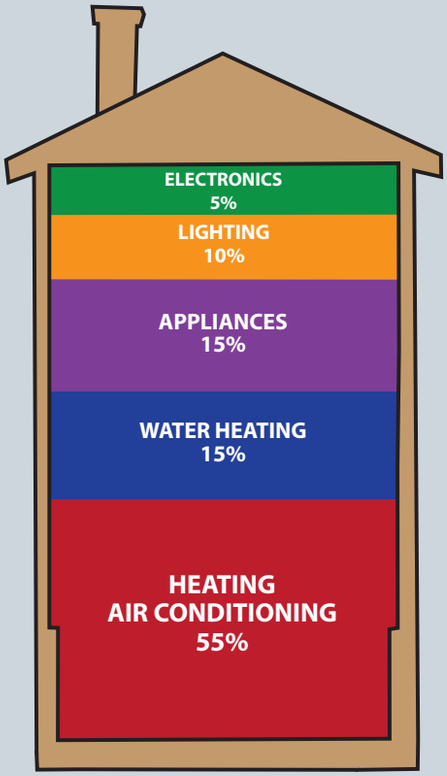


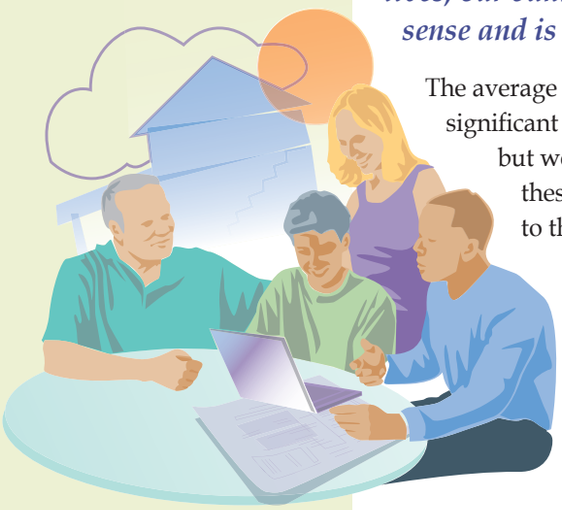
Home Energy Use

A typical Minnesota household uses about 180 million British Thermal Units (mmBTU) of energy every year to heat, cool, light, and operate appliances and electronics.

Because one-fifth of the energy consumed in our state is used in residences, each of us has the opportunity to affect overall energy use and its effects on our environment.

This guide is designed to help you improve the operation, safety, and comfort of your home and to provide guidance for making smart energy efficiency choices.

How, when, and in what form we use energy can have a dramatic effect on our lives, our bank accounts, and our environment. Using energy wisely makes sense and is a goal that we all share.



Building Science

The interactions of the various parts of buildings have become better understood in the past few decades. The efforts of manufacturers, designers, architects, engineers, researchers, and builders to create durable homes that operate safely, comfortably, and efficiently is known as building science.

The average Minnesota family spends a significant amount of money on energy, but we can dramatically reduce these costs—up to 30%, according to the U.S. Department of Energy—by making some simple energy-saving improvements to our homes. In addition to saving money on utility bills, we can protect our homes from moisture damage year-round, reduce problems caused by ice dams on the roof during the winter, significantly cut summer cooling costs, extend the life of houses, and sometimes increase resale values. Furthermore, reductions in energy use also reduce environmental effects, including lowering contributions of carbon dioxide and other greenhouse gasses.

Homes are no longer simple

When many of our homes were built, there was little concern about energy conservation and efficiency, therefore little attention was given to things like insulation and air leakage. Energy was cheap and construction materials and techniques were sufficient for the time.

Over the past several decades our homes (and the things within them) have become increasingly complex. Rising energy costs, along with environmental and other concerns, have increased awareness and driven research into the operations of buildings. The effects of the interactions of structural systems, weatherization components, mechanical equipment, and electrical devices in today's homes are the subject of an entire field of study: ***building science.***

Saving energy benefits everyone

Depending on your home, you may see substantial reductions in your energy use through conservation and efficiency improvements. Even if the annual savings for your home are modest, however, they go on, year after year. Many energy improvements will save enough money to pay for the initial investment in just a few years—some even sooner!

Also, the cumulative effects of thousands of Minnesota families reducing their energy use will pay big benefits to all of us. We use a great deal of energy in our state, and the majority of it is derived from fossil fuels—all of which must be imported into our state. Anything that we can do to reduce the emissions from burning coal and petroleum products will help to slow the rate of climate change and have a positive impact on air and water quality. Additionally, investments in energy-related home improvements help to grow jobs in Minnesota – from contractors and installers to manufacturers and retailers.

What should be done first?

Many people assume that there is little they can do to significantly reduce their energy use and increase the efficiency of their homes. In reality, there are *many* things that typical residents can do themselves and many other things they can hire others to do.

Before you start on any large project, you should know what options you have and what the benefits may be. Today's homes and their systems are much different than what was common 20, 30, or 50 years ago. The interactions between the various components of a house are more complicated, and the effects of systems not performing properly or being out of balance can be costly and sometimes dangerous. The Division of Energy Resources in the Minnesota Department of Commerce strongly recommends having a ***home energy assessment*** (sometimes called a ***home energy audit***) before embarking on your energy improve-

ments or remodeling. This assessment of how your house is functioning can help you decide what needs fixing, what needs upgrading, and what needs replacement. Many people have a follow-up inspection after work has been done to verify the estimated energy savings.

Energy assessment: how your house works

A home energy assessor will evaluate the operation of your home by inspecting and measuring the performance of the building. At *minimum* several things should be included:

- A review of energy bills to identify basic usage and identify opportunities for savings.
- A blower door test to determine air leakage rates.
- Infrared camera scans of walls, attic, and foundation to assess insulation levels and locate possible air leak sources.
- Efficiency and safety testing for combustion appliances (like furnaces, boilers, gas fireplaces, and water heaters) to ensure they are operating properly and not contributing to indoor air concerns.
- A visual inspection for attic, wall, crawlspace, foundation, basement, window, door, and roof problems.

Although many inspectors include some of these tests as part of a general home inspection, it is important to have all of the above tests completed by a trained and qualified energy assessor in order to determine the best approach to improving the energy performance of a home.

When should you get an energy assessment?

Most homes—even recently built ones—can benefit from an analysis of the operation and interactions of the various systems and equipment. There are times when having a professional diagnosis can solve complicated problems while saving time, energy, and money. Consider an energy assessment before:

Replacing equipment such as a furnace, boiler, water heater, ventilator, or air conditioner. Finding and addressing air leakage, insulation, and other issues can help to correctly size new appliances and ensure they will work as efficiently as possible.

Replacing windows, doors, or siding. Properly installed, these improvements can make your house much tighter, which can change the fresh air requirements for some combustion appliances or for the occupants.

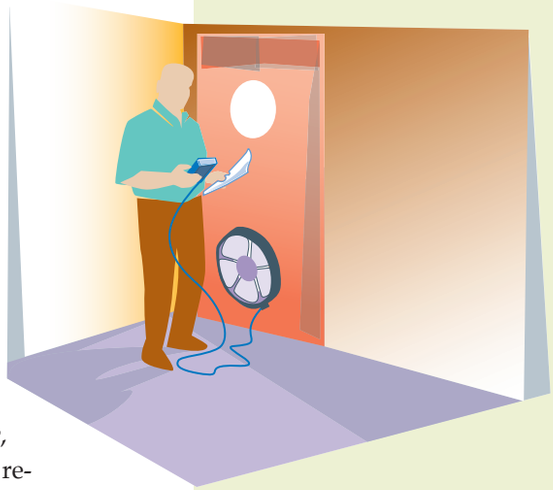
Investing in major remodeling or additions. Knowing the current operation of the home can help determine choices about designs, methods, or equipment options. In addition, pre- and post-construction testing can be used to verify energy performance improvements.

Problem-solving systemic or complex concerns, such as excess moisture (including condensation, mold, mildew, or leakage), uneven heating or cooling, drafts, ice dams, or high energy bills.

Buying or selling a home. Many people already include a requirement for a home inspection as part of a purchase agreement. Although this may identify structural issues, mechanical system problems, code violations, and other health and safety issues, the typical home inspection may not provide a complete look at the energy usage for a home. An energy assessment will highlight energy-saving improvements that can reduce utility costs and improve the health and comfort of future occupants.

How much does an energy assessment cost?

Home energy assessments that meet the suggested minimum requirements cost from $100 to several hundred dollars, depending on the level of detail and the types of tests provided.



Blower Door

Energy assessment tests include a blower door test (above) to determine air leakage rates. Knowing how much and how quickly air is leaking through your home's envelope can help prioritize energy- saving strategies.

Contact your gas or electric utility to arrange for an energy assessment that includes the full range of testing. More comprehensive assessments (for new construction or major remodeling) are available from private contractors specializing in comprehensive home performance reviews.

The payback from this investment will be apparent for many years in terms of increased comfort and safety and reduced energy use and the associated environmental costs.

How hard is it to make energy improvements?

If you have some basic tools and are comfortable with making repairs and improvements to your house, you can handle some of the projects suggested in this booklet and make the most of your energy-improvement budget. Be sure to check with your local municipality for permits and inspections.

However, don't hesitate to call a professional for help if you'd rather not do the work yourself; even with paying to have someone else do the work, the dollars gained through energy savings in upcoming years will be worth the expense. Be sure to check out the "Resources" section at the end of this guide to get tips on hiring contractors.

How do I pay for it?

Although many energy-efficiency projects (caulking windows, weather-stripping exterior doors, or insulating water pipes) will cost just a few dollars, others (insulating exterior walls, air-sealing an attic, replacing a furnace, or adding storm windows) may cost considerably more.

Many utility companies offer incentives on larger projects (furnace replacement, attic insulation, new refrigerator) by giving you a discount on energy bills or sending you a rebate check when the work is completed. Other utilities offer free or discounted services or products (like low-flow shower heads, CFL bulbs, or energy assessments). Contact your local energy utility or visit the Database of State Incentives for Renewables & Efficiency (***dsireusa.org***) for details.

Community nonprofits and neighborhood organizations offer a variety of services and programs, including energy assessments, energy education, free or discounted products, and financing. Contact your city or municipality to learn what is available in your area.

Your bank may be able to help, too. Ask about a low-interest loan designed specifically to cover the cost of your energy-saving projects, or consider a home-improvement loan to fund them. Some banks offer energy-efficiency mortgages, which take into account the reduced energy bills when improvements are made to homes. The Minnesota Housing Finance Agency (***mnhousing.gov***) also offers a Fix Up Fund Loan for home improvements—even if you do the work yourself.

Infrared Scans

Energy assessment tests can include scans from infrared cameras (at right) to pinpoint voids in insulation, air leaks, and moisture problems. Locating the leaks makes it easier to seal and make necessary repairs—and improves the returns on other energy investments you make.

Some Minnesota residents may be eligible for aid from the state Weatherization Assistance Program or Energy Assistance Program. Applications can be made through local service providers; go to ***mn.gov/commerce*** for eligibility requirements, application forms, and contact information.

Finally, for the latest information on tax incentives, rebates, or grant programs from federal, state, or local governments, check out their websites. It is important to find out the specifics (qualifying products, installation requirements, site analysis, inspections, etc.) *before* purchasing products or services. Some programs require approved applications or specific products or procedures in order to qualify for the funding. Not meeting the requirements may jeopardize your incentive, rebate, or grant. A listing of many current programs and links is also available at our website: ***mn.gov/commerce***.

ENERGY STAR®

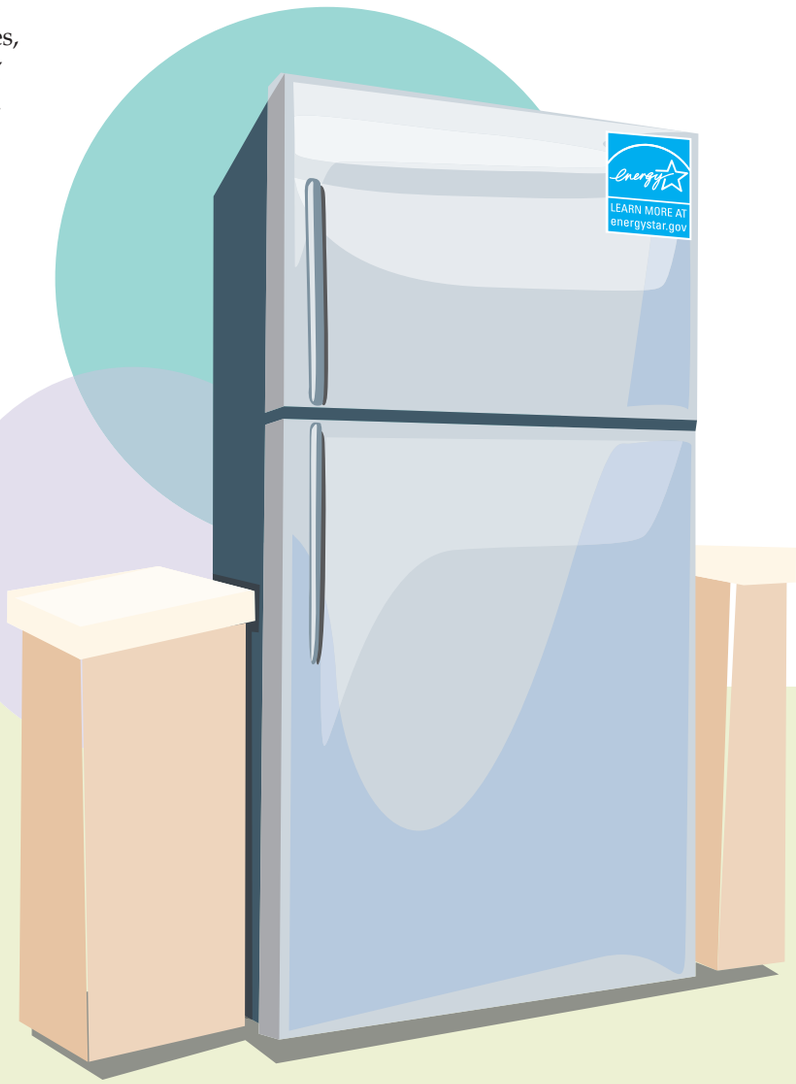
ENERGY STAR® is a joint program of the U.S. Environmental Protection Agency and the U.S. Department of Energy that helps save money and protect the environment through energy-efficient products and practices. Many appliances, lighting products, and electronics can earn the ENERGY STAR® label by meeting these energy-efficiency requirements:

Qualified products must deliver the features and performance demanded by consumers, in addition to increased energy efficiency.

If the qualified product costs more than a conventional, less-efficient counterpart, purchasers will recover their investment in increased energy efficiency through utility bill savings, within a reasonable period of time.

Product energy consumption and performance can be measured and verified with testing.

When shopping for lighting, electronics, and appliances (including heating, cooling, and water heating), always look for the ENERGY STAR® label. To find qualifying products or to compare performance of several products that are ENERGY STAR® labeled, go to ***energystar.gov.***



Simply speaking, the materials of a house that separate the outside from the inside are considered the home's envelope. It is the barrier that keeps us from experiencing the extremes of the outside environment and keeps the inside of our home comfortable, dry, and energy efficient.

The home's envelope includes windows, doors, walls, ceilings, and foundations. Each of these components consist of several elements that go together to create the structure. So, for instance, a wall section may consist of the interior paint, the drywall, the framing lumber, the air barrier and vapor sealing, the insulation, the exterior sheathing, the siding, and the exterior paint. Well-designed components work together to make the envelope as tight as possible.

Home tightening

Every home needs a certain amount of fresh air for the furnace and appliances that burn fuel, for getting rid of excess moisture, and for reducing odors and stuffiness. When this air exchange is controlled, it's called *ventilation*. When it seeps uncontrolled through cracks and holes in the envelope of our home, it is called *air infiltration.* Air that leaks through the ceiling, walls, foundation, and other areas are significant sources of heating and cooling losses in a home—up to one third in some houses. Stopping air leaks is the best way to conserve energy, save money, and increase comfort. The bottom line: If you don't tighten up your home first, other improvements (like windows, insulation, furnaces) may not be as effective.

Infiltration through air leaks can occur in three ways:

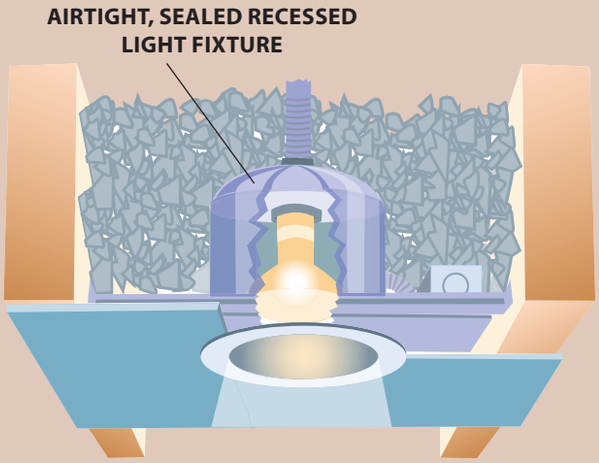
- ***Wind-driven infiltration*** happens during cold-weather months when the wind blows cold, dry air into a house through cracks and openings and forces warm air out. During warmer weather, the wind blows in warm, humid air, forcing cooler air out.
- ***Stack-effect infiltration*** takes place during the natural process of convection. As warm air rises and escapes through cracks at the top of the house, it pulls cold air into the lower areas.
- ***Negative air pressure infiltration*** starts when appliances use air for combustion or when ventilation fans are operated. Outdoor air enters through any available openings to equalize the pressure inside a home. This can be a problem if adequate fresh air for combustion appliances has not been provided. It can lead to a potentially dangerous carbon monoxide risk as fresh air is pulled down chimneys or vents, interfering with their proper operation.

Typically, air infiltration causes drafts and a chilly feeling near windows and doors and in basements. Adjusting your thermostat will not stop the drafts, but sealing hidden cracks and openings will. By stopping air leaks at their source, you'll stay warmer in the winter and cooler in the summer, use less fuel, and reduce your utility bills.

Where do you start?

Fortunately, air infiltration is one of the easiest forms of energy loss to correct. The process requires only a careful inspection of your home and some inexpensive weather-stripping, caulking, and filler materials.

Most people know they should caulk and weather-strip around the exterior of their homes to protect it from the elements. However, it is equally important to protect your home from interior air leaks. Moist interior air can enter the walls and ceiling through cracks and holes, and condensation buildup in those locations can damage or destroy insulation, wiring, wood, or other building materials.



Ceiling fixtures require proper air-sealing

Light fixtures below an unheated attic must be tightly sealed to prevent air from leaking into the attic space. Attic air leaks not only waste energy, they are the primary cause of ice dams.

Methods of sealing include:

- Recessed fixtures. New or retrofit recessed fixtures (including new LED fixtures) should have airtight cans and gasket seals. Existing recessed lights can have special airtight boxes sealed over them from the attic side.
- Flush-mount fixtures. Electrical boxes should be sealed with spray foam around any cracks or openings into the attic.

Caution: Disconnect power to circuit until foam cures!

Look for air leaks

Before research and building science demonstrated the role air leaks play in energy loss, most people assumed that insulation was enough to stop heat flow through a building. Although insulation slows heat transfer, it is easily compromised by air flow, whether driven by outside wind conditions or convection currents within the building. The only way to stop this air movement—and the associated heat loss—is by eliminating the holes and pathways between the inside of the house and the outside.

The first step to tightening up your home's envelope is performing a detailed inspection for air leaks, including an infrared camera scan. This should be part of every energy assessment, and the inspector should be able to show you locations where air is leaking and needs to be sealed. A good rule of thumb is to start by plugging holes and leaks in the attic; then move to the exterior walls, and look for smaller leaks around doors, windows, and electrical switches and outlets; finally check out your basement.

Attic air leaks: more common than you'd guess

Most existing homes have many unsealed penetrations into the attic for wires, chimneys, vents, etc. Sealing will prevent heat loss and damage to building materials.

Hatches and doors to the attic

Weather-strip the edges of the access hole and insulate the back of the attic hatch/door. Don't forget doors to unheated knee wall areas.

Holes in attic floor

Seal all openings around electrical wires, pipes, ducts, and vents with a good general-purpose caulk or spray foam. You may need to use a filler material for larger holes.

Recessed lights and bathroom fans

These fixtures can poke into the attic insulation and create a pathway for air leaks. Caulk around them from below with flexible, high-temperature caulk. Install an airtight box sealed over the top of them in the attic, not only to stop air leakage but to reduce fire hazard from insulation lying against the fixture. When replacing light fixtures, use only air tight fixtures.

Chase for plumbing vent stacks

This channel may run inside the walls of your home, from the basement to the attic, with openings at each floor where the lines branch off. If the chase isn't much larger than the vent where it enters the attic, seal with expanding foam. For larger chases, use drywall, wood, or rigid foam—and caulk or foam around all edges.

Fireplace chimney and furnace/water heater flues

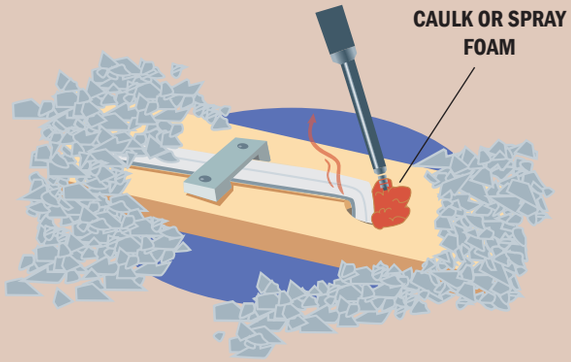
Close the gap between house framing and the chimney and vent flues with metal; seal with red fire-stop caulk.

Knee-wall storage drawers

If storage drawers are recessed into the attic space, build an airtight, insulated box around the backside of the drawers. Don't forget to seal all joints with caulk or sheathing tape.

Other holes

Using the appropriate materials, seal all other holes between the heated space in your house and the attic.



Seal wires and conduit

Electrical wires and conduit often enter attics through the tops of walls. Fill the hole around them with spray foam or caulking.

CAUTION: If your wiring consists of old "knob and tube" style wires, or wires that are worn or broken, they must be protected or replaced prior to insulating and sealing!

Attic air leaks = ice dams

Although many years ago thought of as a problem with roofing or attic ventilation, ice dams are ***actually*** caused by the presence of warm, moist air in the attic, combined with snow on the roof and the right weather conditions. Ice dams occur when heat gets into the attic and melts the underside of the snow on the roof. The melted snow then flows down the roof surface until it reaches a cold spot (such as the eaves or soffit) where it forms a frozen dam, behind which more snowmelt and ice pile up. The ice buildup can back up under the shingles, damaging them and allowing water to leak to the ceilings and walls below.

What NOT to do:

- Installing heating cables will shorten the life of your roof and cost you money to operate.
- Removing the ice with chippers, chemicals, or heat can damage shingles, gutters, and other building components.
- Adding roof vents—including powered vents—will not eliminate ice dams, and often make the problems worse.
- Although additional insulation—especially higher density foam on the top plate of exterior walls—can reduce heat transfer to the roof deck, insulation alone is insufficient.

Air leaks can damage insulation and more

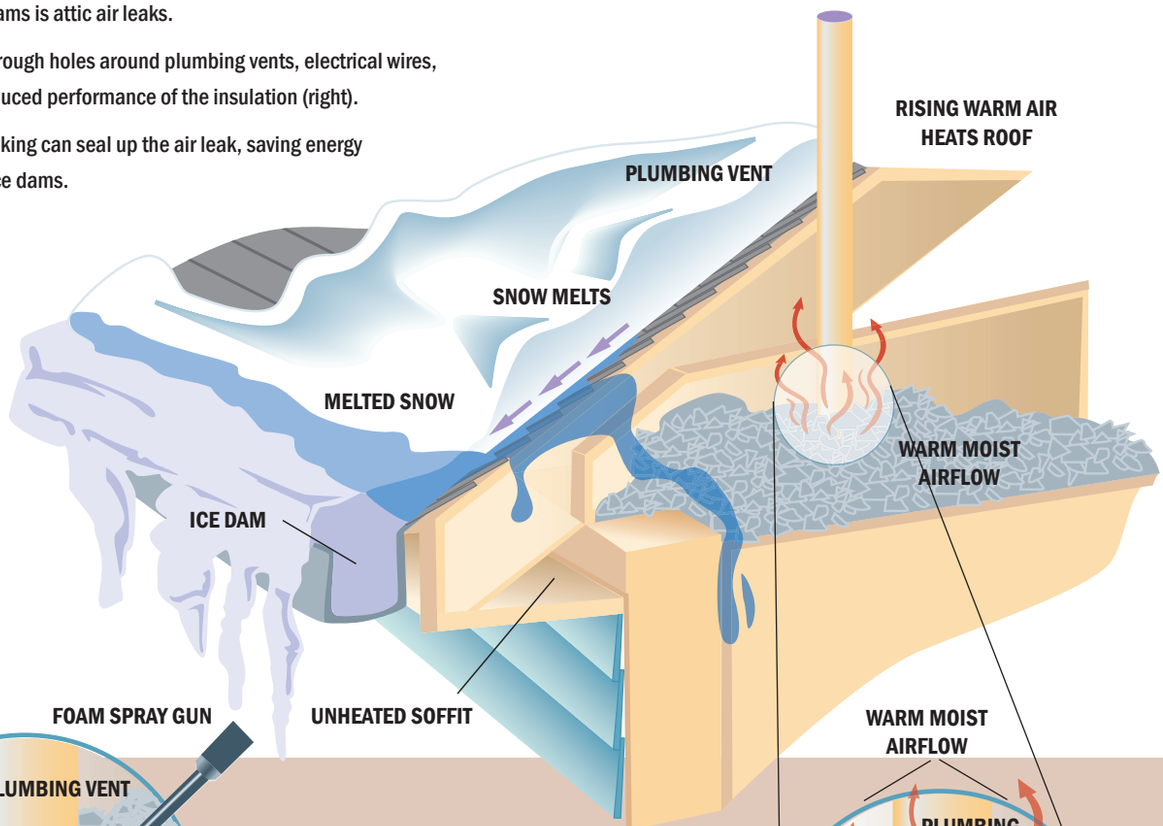
Water vapor carried with the escaping warm air may condense, freeze, and build up in the insulation. When this water builds up, it can soak the insulation (wet insulation has little insulating value), cause plaster and paint to crack and peel, and lead to rot and other structural damage.

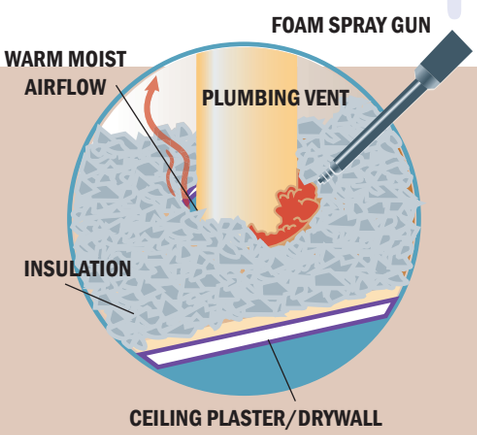
Ice dams

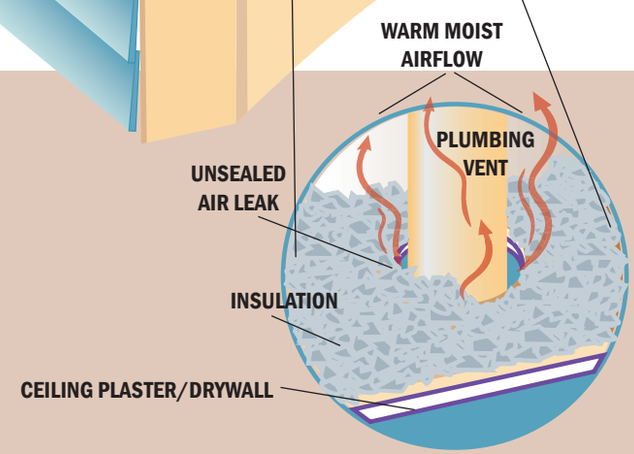
The primary cause of ice dams is attic air leaks.

Warm, moist air leaking through holes around plumbing vents, electrical wires, chimneys, etc. leads to reduced performance of the insulation (right).

Foam spray (below) or caulking can seal up the air leak, saving energy and preventing nearly all ice dams.







Basement air leaks: easy to seal

Most basements have multiple air leakage locations. Because of the physics of the stack-effect (causing warm air to rise), basements are a common source of cooler air leaking in through cracks or penetrations in the foundation or unsealed joints where floor framing rests on the foundation wall. Air then rises through holes around chimneys, vents, wires, and plumbing into the rest of the house. Careful sealing will help to limit warm air entering the attic.

Sill plate and band or rim joist

Caulk cracks between the sill plate and foundation wall using a masonry caulk, and fill cracks between the sill plate and band or rim joist. Then insulate the band/rim joist area by spraying with expandable foam or by cutting foam board insulation to fit and then caulking in place. Do not use fiberglass, as it does not stop air infiltration and because moisture from the basement can get between the fiberglass and the rim joist, leading to mold and mildew.

Chase for plumbing vent stack(s)

Sealing the chase at the basement end, as well as the attic, will reduce the flow of air to the other floors in the house.

Chimney for furnace and water heater

As in the attic, close the gap between framing and chimneys with metal; seal the edges with red fire-stop caulk. Vents made of PVC (plastic) piping can be sealed directly with spray foam or regular caulking.

Hatch or door to crawl space

Weather-strip the edges and insulate the back of the hatch or door.

Openings through basement ceiling

Seal with caulk or foam the hole where the bathtub drain comes down and other holes for plumbing or electrical wiring in the basement ceiling. You may need to use filler material for larger holes.

Basement windows

Using a masonry caulk or spray foam, fill cracks where the frames of the windows are set into the walls. Windows that are not used for ventilation or as fire exits can be caulked shut permanently.

Ducts

In homes with air ducts, there may be gaps where ducts pass through ceilings, floors, and walls. Caulk or foam where the metal duct and the ceiling, floor, or wall meet.

Other holes

Seal cracks or holes in the foundation with caulk, foam, or the appropriate patching material. Don't forget to check where the electrical, gas, water supply, telephone, and cable lines enter the house, and seal on the inside and outside.

DON'T SEAL COMBUSTION AIR SUPPLIES!

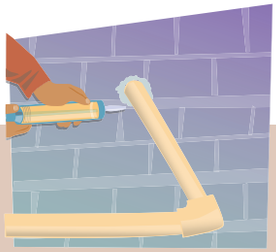
Water heaters or furnaces may have a flexible duct that supplies fresh air for combustion. ***These must be kept open!*** A "J" loop near the duct end can reduce cold air in the basement.

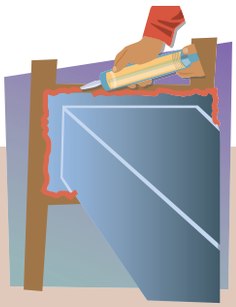
Interior sealing: plug the holes around you

Air leaks in the occupied part of your home are the ones you are most likely to notice. The drafts of air infiltration can be felt around windows, doors, outlets, and fireplaces. The results of these air leaks can frequently be seen as condensation or frost buildups on windowsills or the bottoms of doors.

Window and door frames, trim, and baseboards

- Carefully remove trim and caulk or foam the gap between the wall framing and the window or door jamb (no fiberglass, it doesn't air-seal). If you are unsure how to properly remove and replace the trim, consider hiring someone qualified to do it.





Seal pipes, vents and ducts

There are many places that air can leak into a basement (left). Gas, electric or water lines and vents for dryers, exhaust fans, or high-efficiency water heaters or furnaces that exit through foundation walls or rim joists should be caulked or foamed to prevent air leakage (center). Furnace ducts that rise from basements through floors or walls should be sealed where the metal meets the wood framing (above).

Seal holes, cracks, leaks

Anything that penetrates your walls or ceilings is a potential location for an air leak. Gaps around windows, doors, fireplaces, electrical boxes—even cracks in plaster—can allow air to move between the inside and outside of your house. Seal them up with caulk, weather-stripping, or plaster. And foam gaskets on outlets and switches can increase comfort, avoiding unnecessary energy use.

Seal the outside

There are many places to apply caulking or foam to weather seal the exterior of your home:

- doors and windows;
- vents for furnaces, dryers, water heaters, air exchangers;
- entry points for wires, pipes, cables, faucets.

- If you don't want to remove the trim, you can caulk the edges of trim and baseboard where it joins walls and floors with an interior-grade caulk. Use a clear caulk for hardwood or tile floors and trim with natural wood finishes and paintable caulk for painted trim and carpeted floors. Note: caulk on wall/trim may be a challenge when repainting.

Missing plaster, cracks

Exposed laths indicate a direct hole into wall and ceiling cavities. Repair with plaster or cover with new drywall. Repair smaller cracks using patching material, and repaint.

Windows and doors

Check the weather-stripping on all windows and doors, and repair or replace as necessary. Check the threshold on doors, and replace if worn or leaking air. Replace broken glass and reglaze or putty loose windowpanes. Caulk around moving parts of windows with nonpermanent caulk that can be removed easily. You can also install inexpensive window films (inside only) to cut air leaks.

Electrical switches and outlets

Install foam gaskets and child-safety plugs on all switches and outlets—even on interior walls. Although this may have a very small effect on heat loss from air infiltration, it can have a noticeable effect on comfort, by reducing drafts.

Other holes in exterior walls

Caulk or foam around all ceiling fixtures, heat registers, medicine cabinets, bathtubs, kitchen cabinets, drains, and water pipes where they enter the wall in the kitchen and bath. Also seal any other holes in exterior walls.

Exterior sealing: stop moisture damage, too

Sealing on the outside of your home not only prevents air from entering, it can also prevent damage to siding, walls, insulation, windows, and doors due to moisture intrusion.

Holes for pipes, wires, etc.

Caulk or foam around openings for electric, gas, oil, and water-supply lines; drainage pipes; plumbing for outside spigots; cable TV and telephone cables; mail slots/doors.

Vents

Caulk or foam around dryer vents, heating and cooling system vents, and fresh-air supply vents for fuel-burning furnaces and water heaters.

Windows

Caulk around window frames. If you have combination storm windows, caulk where the metal storm window frame meets the window's frame; don't seal the moisture weep holes at the bottom of the frame. If you have wooden storm windows that must be exchanged for screens in the spring, use non-permanent, non-staining rope caulk to seal the joint between the storm window and the frame.

Doors

Caulk around door frames. Install storm doors if needed and check latches and seals.

Fireplaces:

Waste more heat than they make?

A charming old wood-burning fireplace may seem warm and cheery, but it likely loses more heat from your home than it gives off. Warm air in a home is sucked up the chimney and is replaced by cold air leaking into the house. Especially as the fire dies down, more heat is drawn up the chimney than is created by the fire—and the reduced rate of airflow can lead to backdrafting of dangerous flue gasses and smoke into the living space.

Follow these tips to improve the operation and safety of your fireplace and to reduce your energy losses:

- Improve the seal of the flue damper. To test the damper's seal, close the flue, light a small piece of paper, and watch the smoke. If the smoke goes quickly up the flue, there's an air leak. Seal around the damper assembly with refractory cement, but don't seal the damper closed.
- Install tight-fitting glass doors or an airtight fireplace insert unit. Controlling the airflow in your fireplace improves combustion efficiency by 10 to 20% and reduces air leaks up the chimney. When there is no fire or embers, close all vents and dampers tightly.
- If you infrequently use the fireplace, install an inflatable "chimney balloon" in the flue of the chimney to reduce heat loss. These are available in several sizes and, if properly installed, can significantly reduce heat loss through the flue. Most have a quick-release handle, and many have a safety feature that will instantly deflate the balloon if a fire is started without removing the balloon.
- Many fireplaces and stoves have a source of fresh air to aid in combustion—in fact it is required for most new installations. Fresh air supplies should have a well-sealed damper to prevent air leakage when not in use.
- The joint where a brick or stone chimney meets the wall or ceiling can be a source of air leakage. Foam or caulk to prevent unwanted airflow.

Caulking is easy and cost-effective

Use caulk to permanently seal air leaks in spots such as the cracks and gaps between exterior window and door frames and your home's siding. Generally speaking, you can seal openings up to ¼ inch with caulk alone. For larger gaps, you'll need to add a backing material before caulking or use a spray foam sealant instead.

Older wood windows may have glass panes that are held in place with putty and glazing points. If the putty is cracked or missing, it is a likely air leakage location and must be re-puttied. (Broken panes should be replaced.) Although caulking may be used to repair/replace window putty, it may be difficult to apply neatly and may make future repairs a challenge.

When shopping for caulk, you may be overwhelmed by the choices, so be sure to read the labels and choose the caulk that will work best with the materials you're sealing. The two basic types are latex and silicone, and each have advantages, depending on the circumstances.

Most caulk is sold in tubes that fit a caulking gun; some are available in plastic squeeze-tubes. In addition, some caulks come in aerosol cans; they're a good choice for filling gaps up to ½ inch. Note that some caulks are for indoor use only, and that some are paintable—while others are not.

The benefit of high quality caulk will be a longer-lasting seal; inexpensive caulks may last only a few years.

Before caulking, note the following points:

- Remove old caulk and loose materials completely.
- Make sure all surfaces are dry and free of dirt, grease, or oil; wipe with rubbing alcohol to clean.
- Do not apply when below 50 degrees F or when rain is possible before curing is complete.
- Tape the edges of the crack to keep caulking off adjoining surfaces.

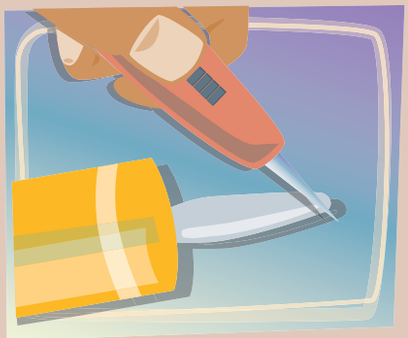
Follow these tips to get a neat, uniform bead of caulking:

- Cut the nozzle at a 45 degree angle at the point where the diameter is equal

Seal fireplaces

There are several ways to improve the energy efficiency of a fireplace, including:

- Seal flue damper.
- Install airtight doors (with good gaskets).
- Install a "chimney balloon" in seldom used fireplaces.
- Insure proper operation/sealing of fresh air supply.
- Caulk/foam where brick/stone meet wall or ceiling.



Steps to caulking

Laying a consistent bead of caulking can take some practice. Follow these steps to provide a good seal:

- Insert tube into gun.
- Cut tip at 45 degree angle at desired thickness; use wire/nail to break seal at base of spout.
- Squeeze trigger while moving tip steadily along joint to be filled.
- Smooth bead with tool or gloved finger, making sure both edges are covered.

to the size of bead you need—near the end for a small bead, farther up for a wider one.

- While applying constant pressure on the trigger, hold the gun at a 45 degree angle and move it slowly along the joint you are sealing.
- Make sure you have enough caulk in the joint to seal both edges and allow for any shrinkage.
- Smooth the caulk with a plastic tool.

Once you have applied the caulk, it takes time for it to dry, or cure. Curing time is described two ways. The tack-free time tells you how quickly the fresh caulk's outer surface will dry—or skin over. The total cure time indicates the time required for the caulk to become completely stable—or reach the point where no further drying or shrinking will occur.

Most caulks pose no known health hazards after they're fully cured. However, some high-performance caulking compounds contain irritating or potentially toxic ingredients, and you should apply them only when there is adequate ventilation; carefully read the manufacturer's instructions and take the appropriate precautions. In addition, make sure pets and people do not come into contact with fresh caulk.

Use spray foam for large gaps

- Expanding foam is ideal for filling larger cracks that caulks can't handle. It comes in aerosol cans and takes a short time to cure. The foam is very sticky and attaches itself quickly to whatever it touches, so be prepared to pick up any messes fast.
- You also can use foam instead of caulk for sealing in your attic; low-expansion foam will stick better to dusty and dirty surfaces than caulk.
- Low-expansion spray foam should also be used to seal the space between framing and jambs in windows and doors; standard expanding foam can cause jambs to warp and affect operation of the window or door.
- When you're working in a large area such as your attic, it may be inconvenient to carry and keep track of several cans of expanding foam. Instead, consider renting a contractor's foam gun, which has a long nozzle and can help you get into tough-to-reach spaces.

Try these materials for special jobs

In addition to the types of caulk and spray foam sealant described above, you may need to use fillers to plug extra-wide gaps. Fillers come in a wide variety of materials—cotton, fiberglass, foam, and sponge rubber—and you can find them in the caulking department of your local hardware store or home center. However, these fillers are not designed for exposure to the elements; you'll need to caulk or seal over them.

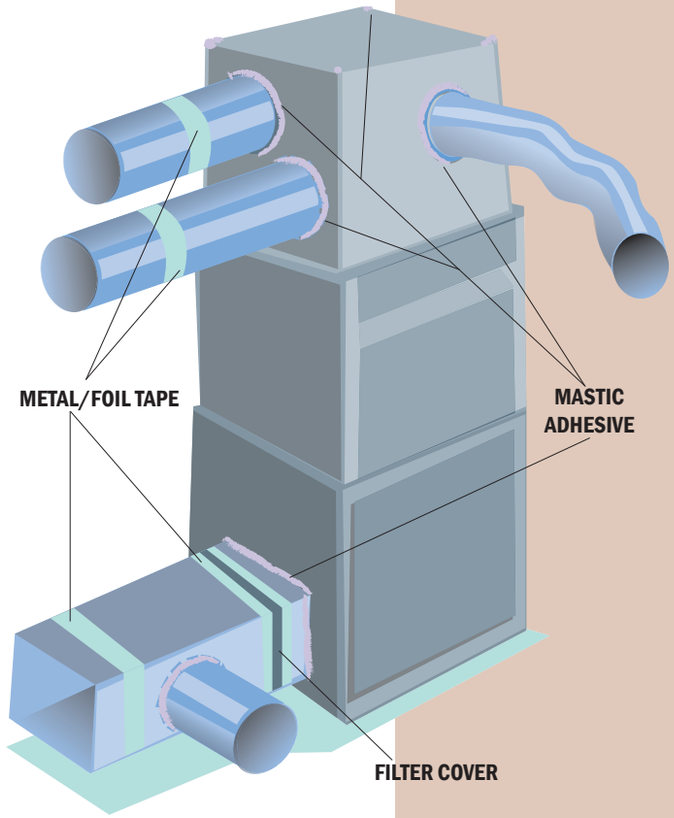
- To close gaps too wide for foam, cut sections of rigid foam insulation to fit and glue into place with expanding foam—before covering with wood or another appropriate building material.
- For winter, use rope caulk to seal windows and other spots that you'll want to be able to open during the spring. Rope caulk is a gray, putty-like material that comes in long strips or rolls. It's easy to install and remains flexible, and you can just pull it off when the weather turns warm. Note that rope caulk will not last longer than a year, and oil-based rope caulk may stain painted areas.

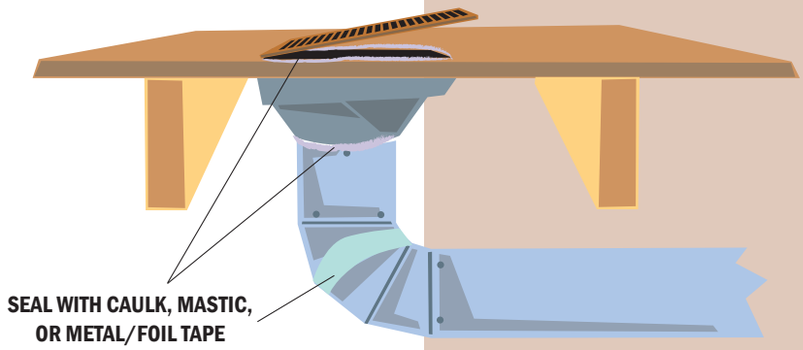
Keep heated and cooled air in ducts

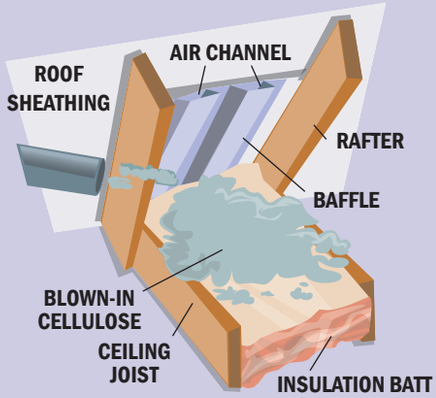
The ducts for a forced-air heating and air-conditioning system can be one of your home's biggest energy wasters, especially if those ducts run through unheated or uncooled spaces (like attics or crawl spaces).

Properly sealed ducts can deliver heated/cooled air where you need it, instead of leaking out where you don't. This allows your furnace/air conditioner to work less to make you comfortable.

- Check the ducts for air leaks, including around the filter cover. Repair leaking joints first with sheet-metal screws; then seal joints with either latex-based mastic with embedded fiberglass mesh or metal/foil tape (UL 181). Don't use plastic or cloth duct tape because it will harden, crack, and lose its adhesion.
- Wrap ducts in attics/crawl spaces with special duct insulation. Seal all insulation joints with the appropriate tape.
- Make sure ducts fit tightly to the register openings in floors and walls; if they don't, seal them with caulk.
- Seal return ducts, too, so you won't be breathing basement or crawl space air.
- Make sure registers and baffles are adjusted properly to distribute heated and cooled air to where you need it. For example, in the winter close registers in unused rooms.
- Don't confuse ***duct-sealing*** with ***duct-cleaning!*** There are no energy-related benefits to duct-cleaning.







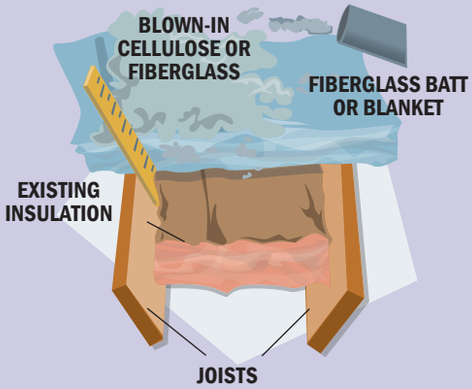
Attic insulation options

There are several good options for installing additional insulation to an attic. Unless wet from roof leaks or excess moisture from the building below, there is no need to remove existing insulation. Your choices include:

Batts or blankets. Fiberglass is available in a variety of thicknesses and widths, and can be laid on top of existing insulation. If the top of the existing insulation is below the top of the ceiling joists, fill the spaces between the joists first. Then lay batts or blankets perpendicular to the joists to provide the best coverage. Carefully cut around pipes and truss pieces, and don't bunch or fold the fiberglass.

Blown-in. Generally composed of cellulose (made from recycled newspaper) or fiberglass fibers, blown-in insulation does a much better job of filling around framing and providing a consistent layer of insulation. Blown-in insulation can be applied directly over existing insulation. Proper application requires a special machine and moderate skill.

Regardless of which insulation material is selected, plastic baffles must be inserted between rafters extending past the wall plate to keep insulation from falling into soffits and to provide ventilation. And every attic insulation project must also include sealing of air leaks!



Insulation slows the heat flow through a building's envelope. It works year-round to make your home more comfortable and energy efficient. In the winter it slows heat loss and in the summer reduces heat gain and helps keep your home cool.

Adding insulation to your home can cut heating and cooling costs 15% or more, depending on factors such as the amount of existing insulation in your home, house size, air leaks, personal energy use, and living habits. Many variables affect the exact amount you'll save, but insulating your home is usually a wise energy investment.

While every house is different, the basic rule of insulating is the same for all homes: Install insulation on any surface separating a heated space from an unheated space. Even if your home already has some insulation in these areas, there can be great benefits in adding more insulation, especially in your attic.

Recommendations vary for the amount of insulation necessary in particular locations for peak energy savings, depending on factors such as climate conditions, the sections of your home being insulated, and the kinds of materials used in your home's construction.

Insulation is rated by R-values

The R-value (or thermal resistance) of insulation is a measure of its ability to resist heat loss or heat gain. The higher the R-value, the better a material insulates. An insulation's R-value is based on its performance with no air movement, therefore the *effective* R-value of a particular insulation may be much lower than its *rated* R-value, ***especially if the insulation is not properly installed—or if air leaks are not sealed before the insulation is added.***

Blown or loose-fill insulation materials will settle after installation, reducing their effective R-value by 10 percent or more. (Dense-pack cellulose for use in wall or floor cavities, however, has negligible settling.) Be sure to check the manufacturer's specifications before you buy insulation, and follow supplied charts to ensure adequate long-term coverage.

Finally, some types of insulation—such as dense-pack cellulose, polyurethane, and polyisocyanurate—combine both an air-sealing barrier and insulation in one step. Some insulation products also serve as a vapor retarder when properly installed. When comparing products, carefully consider the costs and benefits of doing the entire job: insulation, air-sealing, and vapor retarder.

Start in the attic

Your home can lose a significant amount of heat through the top, so the best place to start insulating is the attic. Compared to other parts of the house, access to the attic is relatively easy, therefore the cost of attic insulation projects is considerably lower. It is also the easiest place for "do-it-yourselfers" to begin. You can install loose-fill, batt or blanket insulation over existing insulation. If you choose to use a blown-in insulation (such as fiberglass or cellulose) or a sprayed-on insulation (such as polyurethane or polyicynene), you'll probably need to have it professionally installed.

Many home attics in Minnesota have some insulation; most can benefit by adding more attic insulation. Increasing attic insulation to an R-50 can provide a good barrier to heat loss. To determine the present R-value of your attic insulation, have an energy assessment; you can also measure the height of the insulation and multiply

times the R-value per inch of the material that is in place (2.5 to 4.0 per inch, on average). Roughly 12 to 20 inches (depending on the material used) will provide an R-50 rating. Although it generally won't hurt to add more, the return on the investment decreases as the R-value increases above R-50.

Things to look for if you do it yourself

If you are insulating your own attic, there are several things to check out to ensure the best possible results:

- Check for attic air leaks around pipes, wires, and chimneys and seal them up.
- Make sure baffles are installed at eaves to allow ventilation and prevent "wind-wash" of insulation.
- Inspect wires and fixture and junction boxes before covering with insulation.

What about open ceilings or flat roofs?

Insulating a cathedral ceiling, A-frame house or flat roof is an especially difficult job, because there is little or no space between the ceiling and roof. One option is professional installation of spray-in insulation materials; alternatively, building out of roof rafters to allow additional insulation is also possible. A third option is to have foam insulation applied beneath the roof deck during a re-roofing project. All options must also provide ventilation to current code.

Insulating the "story-and-a-half"

Many homes built in the middle of the 20th century were single-story with a large "expansion attic" above. These areas frequently became finished living space—and were often uninsulated or insulated improperly. Because of the complexity of the framing and the difficulty gaining access to some of the areas that need to be insulated, the story-and-a-half can present an insulation and air-sealing challenge. But, considering that so much heat can escape through the top of a building, proper air-sealing and insulating of these structures is essential.

If the attic space has never been framed or finished, insulating and air-sealing can follow the standard practices as if it were new construction. If, however, knee walls and ceilings are in place, special care must be taken to ensure a good result. (Note that the same approaches to sealing and insulating also apply to homes that have an attic above a second floor—a "two-story-and-a-half.")

Four surfaces must be sealed and insulated

There are four parts to a typical story-and-a-half framing system (along with the vertical gable ends). Each part requires a different approach for proper air-sealing and insulation.

Ceiling

The flat ceiling is similar to an attic floor. Batts or blown-in insulation can be installed between and over the ceiling joists. Access to the space may be through an attic door or through roof vents. If the knee wall space is unheated, baffles must be installed for ventilation. Air-sealing of all penetrations (access doors, wires, fixtures, vents) must also be done.

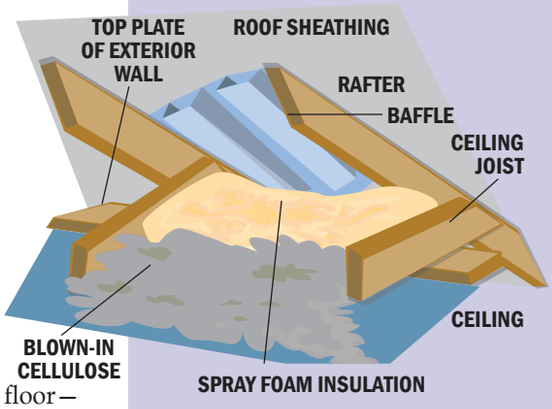
Slants

The slanted part of the wall should be treated like a cathedral ceiling. Building out the rafters to allow for additional insulation and ventilation is the best solution. Professional installation of a spray foam is also possible, as well as rigid foam under the roof decking. If the space behind the knee wall is to be kept as heated storage, the insulation needs to extend all the way to the floor along the slants.

Walls

The vertical walls (knee walls) can be insulated and sealed just like vertical walls on the lower part of the house, with the following exceptions:

- If the knee wall space is heated storage, no knee wall insulation is required (see slants, above).



Insulate the top plate to reduce ice dams

In most homes, the top of the exterior wall (the "top plate") is very close to the roof deck because of the slant of the roof. This means there is much less space for insulation, especially when baffles for ventilation are installed. Less insulation means more heat loss, and it is right at the location prone to ice dam formation.

The solution is to apply an insulating material with a higher R-value, such as a spray foam (above), to increase the effectiveness of the insulation at that critical location. There are challenges, however, in gaining access to the space. Here are three options:

- An insulating contractor can often access hard-to-reach top plates from inside the attic with the use of an extended "wand" as part of their spray equipment.
- Soffit pieces can be removed and access gained from underneath and outside of the attic.
- If a re-roofing is planned, roof boards or plywood can be removed to gain access from the top and outside of the attic.

- If the knee wall space is unheated storage, the knee wall should be insulated like any vertical wall. Gypsum (or foam boards for additional insulation) can be installed over the studs on the knee wall side to protect the fiberglass. Air-sealing of all penetrations (access doors, outlets, wires, vents) must also be done. If there are built-in drawers or cabinets, a sealed and insulated box must be built around them on the knee wall (cold) side.

Floor

The space between the floor joists beneath the knee wall is often neglected in terms of insulation and sealing—and is often the most difficult to access. If the knee wall space is heated storage, no floor joist insulation is required. Otherwise, insulation must be installed beneath the floorboards from the outside junction with the roof to a point beyond the knee wall. The methods include:

- Removing floorboards to place batts between the joists. A "plug" of gypsum or foam insulation board should be installed beyond the knee wall, caulked or foamed to prevent air leaks.
- Drilling holes in the floorboards to install dense-packed cellulose insulation. Because dense-packed cellulose provides an air barrier, no additional air-sealing is required.

Head for the basement

Most Minnesota homes have basements with either concrete block or poured-concrete walls. While these make sturdy foundations, they're poor insulators and have a very low R-value. Therefore, an uninsulated basement can account for a significant amount of a home's energy loss.

Check the top of the basement foundation

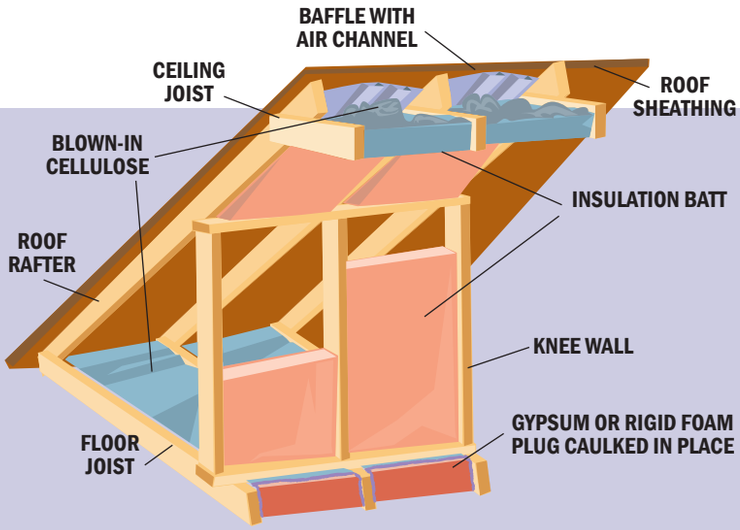
The wooden rim (or band) joist area—where the house's wooden structure rests on the concrete foundation—is the best place to begin. It's the simplest and least expensive basement area to insulate, and it will bring you the highest return on your investment. And, because it is usually above ground, there is little risk of moisture migration from the exterior.

Insulate with cut-to-fit pieces of rigid, extruded polystyrene or polyisocyanurate foam, caulked or foamed into place, to avoid air leaks. *Fiberglass is not recommended* because it does not provide an air-tight seal. Moisture from the basement can migrate through the fiberglass where it condenses on the cooler rim joist, leading to potential problems with mold or wood rot.

Insulating the foundation walls

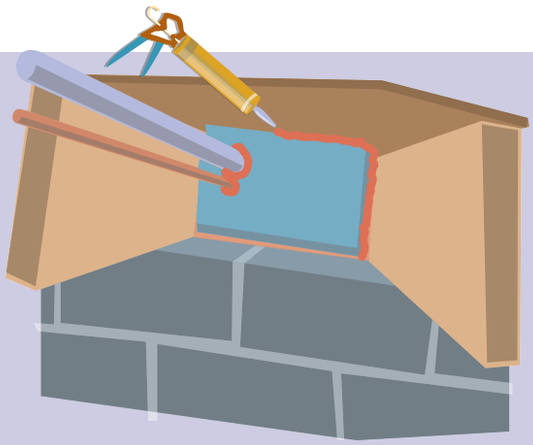
Concrete (whether block or poured) is extremely porous, and unless sealed from the outside it is a likely source of moisture into a basement. Because migrating and condensing moisture can be trapped behind wall insulation—leading to mold and mildew growth—insulating basement walls is challenging. Even historically dry basements can be subjected to water migration or seepage during severe storms or flooding. (Don't be misled by claims that products that are painted or applied to interior basement surfaces will prevent moisture from seeping through walls or floors—they can't.)

Attaching wooden studs to the foundation wall and installing fiberglass insulation (a method used in previous years) is ***no longer recommended***. The wood and insulation can become a good medium for growing mold and mildew when moisture finds its way between the foundation wall and the insulated wall.



Knee wall insulation

Attention to detail is critical when insulating and sealing the knee wall area in an expansion attic. Because heat rises, any insulation voids or unsealed cracks will allow large amounts of air to escape, reducing thermal performance and increasing energy costs.



Rim joist insulation

Install rigid foam pieces, carefully sealing edges and around pipes, wires, and vents to prevent moisture from damaging wood framing. Alternatively, the application of a spray foam (usually done by a contractor) can provide good insulation and air-sealing.

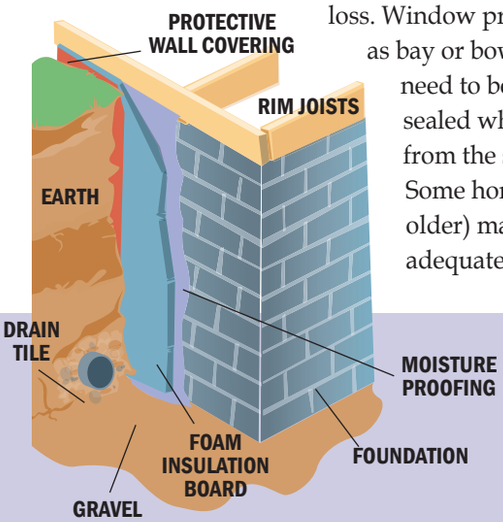
Interior basement walls—that have a very low risk of moisture potential—can sometimes be insulated successfully with rigid foam panels; proper assessment and installation by a professional contractor is strongly suggested, however. Attention to details—such as proper sealing—can reduce the chances of damaging mold and mildew problems. It is important to note again, however, that foundation walls that are not sealed from the outside will potentially allow moisture to migrate into the basement.

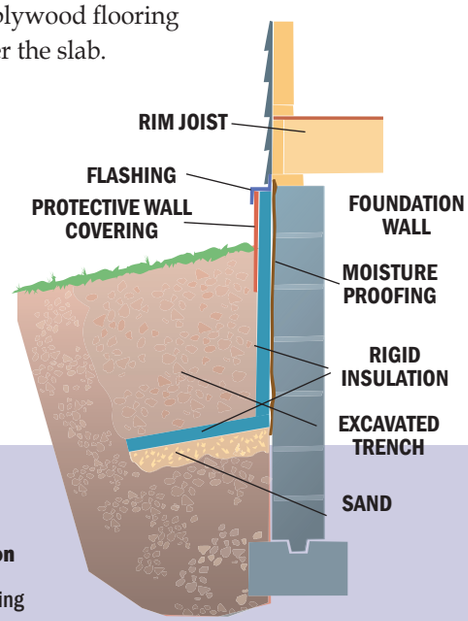
Unfortunately, the recommended approach to basement insulating can also be costly: removing the soil outside the house all the way to the footing, sealing the foundation wall, providing for proper drainage, then insulating with rigid foam on the exterior of the wall. An alternative approach uses a high pressure sprayer to remove soil from alongside the foundation wall. The resulting narrow trench is filled with a specially formulated spray foam that provides insulation as well as moisture control. A project of this magnitude requires hiring an experienced contractor.

Insulate floors over unheated spaces

Floors over a basement that have a heat source such as a furnace, boiler, or wood stove don't need to be insulated. However, floors over an unheated area such as a garage, a porch, or open ground can be a source of considerable heat loss. Window projections (such as bay or bow windows) also need to be insulated and sealed where they protrude from the surrounding wall. Some homes (especially older) may not have had adequate insulation or air-sealing at these locations. A professional insulation contractor can often access these challenging locations:

- ***Cantilevered floors*** over an exterior wall can be sealed and insulated with spray-in polyurethane, polyicynene, or blown-in cellulose insulation through small holes on either the interior or exterior. Air-sealing of joints and cracks (with spray foam and other products) is critical to prevent moisture from damaging insulation or building components.
- ***Bay or bow windows*** can be insulated with rigid board insulation or spray-in foam at the "floor" and the "roof" of the projection.
- ***Tuck-under garages*** are particularly important to air-seal and insulate. The risks of fumes (from vehicles or things stored in the garage) migrating into the house above can be significant. Sealing all joints and cracks with spray foam and then applying rigid foam insulation covered with gypsum board is a good option.
- ***Slab-on-grade*** homes that were not insulated properly during construction can sometimes have rigid insulation board with plywood flooring installed over the slab.





Basement Insulation Options

The best way: exterior

Although usually more costly (in an existing building), the insulation of foundation walls from the outside is the best way to provide thermal efficiency and protection from moisture problems, mold, and mildew. Proper sealing and drainage are important in any exterior foundation insulation project.

Another exterior option

An alternative to insulating and sealing all the way to the footing on the exterior foundation wall is to do it part way (sometimes called the apron method). Dig a trench about two feet wide and about 18 inches deep and insulate the wall with a vertical piece of rigid foam. Then place a horizontal piece of rigid foam slanted away from the wall at the foot of the vertical piece. This approach will provide some insulation for the basement wall and (if done properly) can aid i n reducing the intrusion of water through the basement wall. Attention to detail regarding flashing, surface preparation, and joint sealing will reduce the likelihood of basement water problems.

From the inside—usually not a good idea

Because of the risk of mold and other moisture problems, the insulation of interior basement walls is very challenging to do properly. Unless basements have a very low risk of moisture potential, it is better to leave the walls uninsulated on the interior to allow drying and reduce mold and mildew issues.

If you have a crawl space ...

Any part of the house that is heated must be separated from unheated space by insulation and air-sealing, including crawl spaces. If your crawl space has a dirt floor, cover it with polyethylene sheeting before insulating and extend the plastic several inches up the walls. As with a basement foundation wall, the preferred method for insulating is from the outside. Other options include:

- Insulate crawl space foundation walls and the floor to a value of R-10 or higher with a rigid foam insulation, appropriately sealed.
- Insulate between the floor joists with sprayed foam or rigid foam to a minimum of R-10. (Because of the difficulty of a proper air-sealed installation, fiberglass batts between the joists is not usually recommended.)

Regardless of the method used, crawl space ventilation is not recommended, due to moisture and condensation concerns.

Check out your walls

Generally speaking, homes built before 1960 do not have insulated walls, or are insulated with products that are inadequate by today's standards. Even some homes built after that were not carefully or completely insulated. The benefits of adding insulation to exterior walls can be very high, depending on the situation. There is a simple way to determine whether your walls contain insulation: Turn off the electricity and remove an electrical outlet or switch plate on an exterior wall; using a flashlight, look behind the electrical box for insulation. This will tell you only whether or not you have any insulation material in your walls; the integrity of the installation can only be determined through an energy assessment that includes infrared imaging.

When should you add wall insulation?

Insulating your walls may be a good idea when there is less than one inch of insulation in the wall cavities (typically, walls have space for 3½ inches of insulation) or if infrared imaging reveals significant voids or gaps. If remodeling work is planned involving exterior walls, adding wall insulation (and proper air-sealing) is relatively easy and affordable.

Fiberglass batts

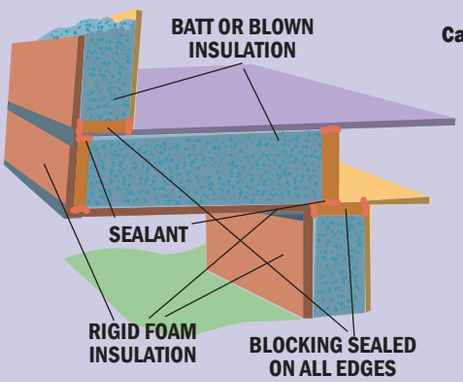
If wall cavities are accessible from the inside (because plaster or gypsum has been removed), installing fiberglass batts is relatively straightforward. Careful cutting and fitting around wires, electrical boxes, pipes, and vents is very important. When fiberglass is compressed, it loses significant insulating value; when "bunched up" (around wires, for example) there can also be voids and gaps. Installing a vapor retarder over the fiberglass is also important; seal all seams with sheathing tape. Outlets and switches should have an air-tight box installed that is taped or caulked to the vapor retarder.

Dense-pack cellulose

Drilling small holes (from the inside or outside) and adding dense-pack cellulose can provide good insulating value, and excellent air-sealing as well. Installed by an experienced contractor, dense-packing sidewalls also requires patching and finishing the access holes (which can be a challenge with exterior finishes).

Other wall insulation options

- Removing old siding and installing new siding provides several insulation options. Dense-pack cellulose can be blown into empty stud cavities through holes in the exterior sheathing before the new siding is installed. Another option is to install rigid foam beneath the siding to provide additional wall insulation and provide a thermal break



Cantilever insulation

Any projection over an exterior wall should be insulated and sealed to prevent heat loss and moisture intrusion. If fiberglass is used to insulate, sealant (caulking or spray foam) should be applied at all framing joints and cracks. Rigid foam boards should be taped at corners and joints.

for the wall framing. (Don't be fooled by claims that foam "backer-boards" placed behind aluminum or vinyl siding offer insulation value; they are designed to support the siding, not insulate the walls.)

- Polyurethane or polyicynene foams can be sprayed into open wall cavities, from either interior or exterior. These products provide a very high R-value and a good air barrier and vapor retarder as well. Because of the complexity of the equipment and application process, spray foams are only installed by experienced contractors.

Insulation needs a vapor retarder

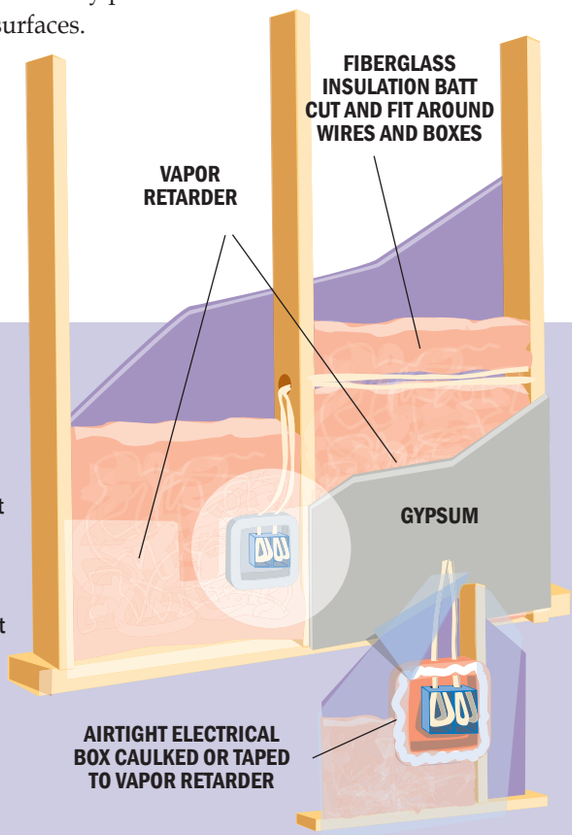
As with a glass of ice water, condensation occurs when warm, moist air touches a cold surface. When this happens in your home, it can cause mold, mildew, and damage to building materials and reduce the effectiveness of the insulation.

A vapor retarder slows the movement of air and water vapor through building materials; in fact, a good vapor retarder will allow very little moisture to pass through. Some vapor retarders also serve as air barriers. A good vapor retarder and good air-sealing can improve the energy-related performance and durability of your home.

Most homes built before 1970 do not have a separate vapor retarder component; however, the predominance of oil-based paints in those homes usually provides an adequate vapor control function.

Whenever you install insulation, always include a vapor retarder. If you're adding insulation to an area that already has a vapor retarder, you do not need to add another one. Vapor retarders include:

- Polyethylene sheets are most frequently used as a vapor retarder, but they may not be a good choice if you have central air conditioning; hot, humid outside air can be driven through the wall assembly and condense in the cooler wall cavity, leading to potential moisture problems.
- Foil or kraft paper often is part of fiberglass batt or blanket insulation. The vapor retarder should face the interior of the building.
- Most rigid foam board insulation acts as a vapor retarder when installed under an interior covering material such as drywall. If the foam is also intended to be an air barrier, the seams should be taped—for both interior and exterior use—to improve its performance.
- Sprayed-in foams (such as polyurethane insulation) may not need a vapor retarder when installed properly. Check your local building codes for vapor retarder requirements with spray foams.
- "Smart vapor retarders" are a relatively new product that allows moisture to migrate out of a wall cavity under certain conditions. Consisting of a film that is applied over un-faced fiberglass or other insulation (similar to polyethylene sheets), smart vapor retarders have a high resistance to water vapor under low-humidity, winter conditions, thus slowing moisture movement from the inside environment into the wall. During high-humidity, summer conditions, the permeability adapts, thus permitting any trapped moisture in the walls to migrate to the interior.
- Finally, vapor retarder paint (often a primer sealer) can provide adequate vapor control and can be applied to new or previously painted interior surfaces.



Wall insulation

Fiberglass batts (right) can be applied if walls are opened to the interior. Care must be taken to not compress or leave voids in the insulation in order to maintain thermal performance. Penetrations (such as wires, electrical boxes, pipes) must be carefully sealed with caulking or spray foam to prevent air leakage.

Dense-pack cellulose (made from recycled newspapers) is an excellent choice for insulating and sealing walls (left). Installed through holes drilled from either the outside or inside, it is often the most cost-effective way to insulate sidewalls in homes with no existing wall insulation.

Types of insulation

Insulation does its job by creating small pockets of air that slow the transfer of heat through the insulation—in exactly the same way that a blanket works. Types of insulation vary according to use and location. Among the insulation options that work best in Minnesota's cold climate are the following:

Batts or blankets

Material	Fiberglass, rock (mineral) wool.
R-value/inch	3.1 to 4.0
Method of installation	Fitted between studs, joists and beams.
Where applicable	All unfinished walls, floors and ceilings.
Advantages	Do-it-yourself. Suited for standard stud and joist spacing that is relatively free of obstructions.

Loose-fill

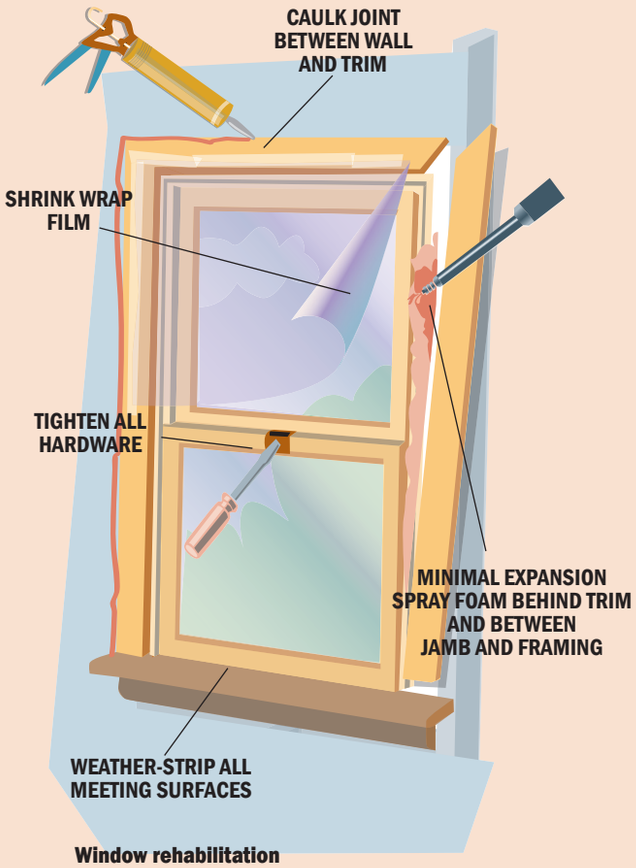
Material	Cellulose, fiberglass, rock (mineral) wool.
R-value/inch	2.4 to 4.0
Method of installation	Blown into place (attics) or dense-packed (cellulose, walls).
Where applicable	Enclosed existing wall cavities or open new wall cavities. Unfinished attic floors and hard-to-reach places.
Advantages	Commonly used for retrofits (adding insulation to existing finished areas). Good for irregularly shaped areas and around obstructions. Dense-pack cellulose in walls also provides an air barrier.

Rigid foam

Material	Extruded polystyrene foam (XPS), expanded polystyrene foam (EPS or beadboard), polyurethane foam, and polyisocyanrate foam.
R-value/inch	3.5 to 7.5
Method of installation	Interior applications—must be covered with ½-inch gypsum board or other building-code approved material for fire safety. Exterior applications—must be covered with weatherproof facing.
Where applicable	Basement rim joists, exterior walls under finish materials and vented low-slope roofs.
Advantages	High insulating value for relatively little thickness. Can block thermal leak when installed continuously over frames or joists. Can provide both air barrier and vapor retarder.

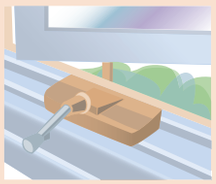
Spray foam

Material	Polyurethane, polyicynene.
R-value/inch	3.6 to 7.0
Method of installation	Sprayed onto surfaces or behind a net facing.
Where applicable	Open wall cavities, between roof rafters.
Advantages	High insulating value for relatively little thickness. Provides good air barrier. Some products provide vapor retarder.



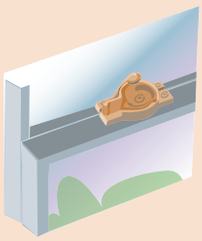
Window rehabilitation

The most important energy-related function of a window is to prevent air leakage. Even aging windows can be repaired and tightened, improving energy efficiency and extending their life by many years. Windows that are difficult to repair (because of structural damage or challenges finding replacement parts) can be air-sealed easily and cheaply by applying shrink wrap film on the interior.



Window hardware

As windows are used over time, the hardware can become loose or worn, leading to incomplete sealing when closed. Tighten loose screws or reposition hardware slightly to make a firmer attachment. If damaged, replace closing hardware with parts from the manufacturer. Some replacement parts are available through hardware stores as well.



Windows, doors, and skylights are often a weak energy link in home construction, accounting for a significant portion of a home's heat loss in the winter and heat gain in the summer.

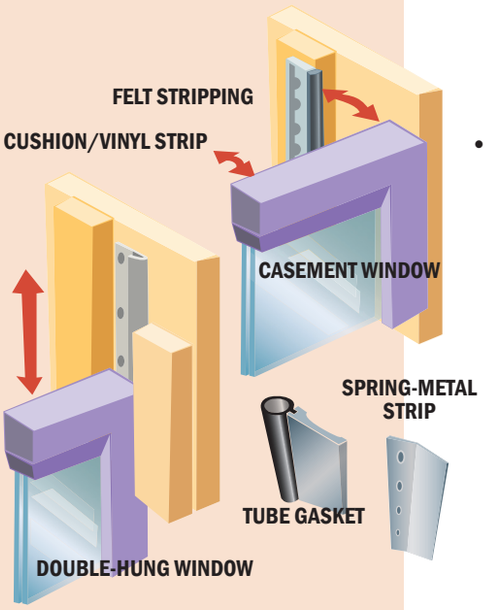
Many complaints about condensation or frost on windows and doors and about drafts or temperature discomfort in a house are actually caused by air leaks. Although new technology has greatly improved the energy efficiency of modern products, any *fenestration* (an opening, such as a window or door) will be far less efficient than the surrounding wall structure—especially one that is properly insulated and air-sealed. Because new windows and doors are relatively expensive, it is important to determine when repairs make sense and when replacement is the right choice.

When to repair windows and doors

As homes age, building materials age as well, losing strength, flexibility, and usability. This disintegration process can be slowed considerably, and—surprisingly to many people—replacement of windows and doors may not be necessary if the problems are not structural. Simple maintenance and inexpensive repairs (like caulking, weather-stripping, and painting) can extend the life of windows and doors considerably—and for much less than the cost of new components.

Many older homes have windows and doors that were installed to the standards of their day; as building knowledge has improved, so have the components and methods of installation. Even relatively new products can suffer from inadequate materials or poor installation, however. Here are some common window and door problems and fixes:

- ***Damaged components.*** Cracked or missing panes of glass in doors or windows are obvious locations for leakage and energy loss. Replacement is best, but sealing with caulking can be a good temporary fix. Older windows may use a glazing compound (putty) to hold the glass to the frame. As this ages it dries and comes loose, allowing air to leak through, and should be replaced. Other damaged parts may be able to be repaired with wood putty or epoxy.
- ***Defective air-sealing.*** The gap between jamb and framing may be empty or stuffed with fiberglass insulation. Gently removing inside trim will reveal this space, allowing for application of a window and door spray foam product or caulking. If re-siding, access to this space may be possible from the exterior. If access to the space is difficult, a small bead of paintable caulking can be applied to the joint between the trim and the wall. A quick and inexpensive (but single-season) solution for leaky windows can be the application of shrink-wrapped film on the inside.
- ***Loose or missing hardware.*** Latches, hinges, and the operating parts for crank-out windows can become loose or damaged through repeated use. Often a simple tightening of screws will



Weather-stripping

The performance and durability of windows is tied closely to weather-stripping. Materials such as polyurethane, mylar, neoprene, and EPDM rubber are ideal for Minnesota's climate because they remain flexible under temperature extremes.

As with windows, weather-stripping of doors is important, especially since most doors are opened and closed more frequently than windows. Materials such as polyurethane, mylar, neoprene, and EPDM rubber are also recommended for doors. Special attention should be paid to the threshold seal at the bottom of the door; subject to considerable wear from foot traffic, it should be durable and flexible.

In addition, since all weather-stripping will have to eventually be replaced, it is important to have materials that are easy to remove and install and are readily available.

do the trick. If parts are bent or damaged, replacements may be available from the manufacturer or from a local building supply store.

- *Improper exterior flashing.* Properly installed flashing diverts water to the outside of the siding, preventing intrusion into the wall or window/door unit. Water that seeps into the wall cavity or structural components can lead to rot and voids, which can permit air to leak around the window or door. If water damage has occurred, removal of the exterior trim (and perhaps siding) and re-doing the flashing is the only way to remedy the problem. If damage to wall assemblies or insulation has occurred, repair and replacement may also be required.
- *Worn or damaged weather-stripping.* Weather-stripping prevents air infiltration around windows and doors by sealing the gaps between the frames and moving parts when they're closed. With weather-stripping, one or both surfaces of a door or window must be free to move—as opposed to caulking, which builds a permanent seal between two stationary surfaces. Attention to detail is critical when installing weather-stripping in order to avoid problems with window and door operation. Along with windows and exterior doors, you should also weather-strip all doors that lead to unheated areas, such as the attic, garage, or unheated basement.

Types of weather-stripping

Weather-stripping comes in several sizes and shapes (often designed for specific uses) and may be made from metal, plastic, vinyl, rubber, felt, or foam—or a combination of these materials. Extensive testing has shown that tubular weather-stripping provides the best seal. However, on doors or swinging windows, this type requires the most closing pressure, which may be difficult for children, the disabled, or the elderly. 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, the installation of neoprene, urethane, silicone, or rubber weather-stripping is recommended, because these materials create good air-seals with minimum closing force at all temperature ranges and have long, useful lives.

Many window and door manufacturers have replaceable weather-stripping kits that can be ordered and easily installed; check with the manufacturer or your building supply store for information about your specific units.

You can also buy weather-stripping by the foot or in kits at a local hardware store or home center. You can calculate the amount of weather-stripping you'll need by measuring the perimeter of all the windows and doors to be weather-stripped. It's a good idea to add five to ten percent more for waste. However, before you buy anything, determine what kind of weather-stripping you want to use. If possible, remove a small portion of the existing weather-stripping (or take a picture) to compare it with what is available. Checking the size of the gap between the fixed and moveable sections of your doors and windows, as well as thinking about the amount of expected wear and tear in these areas, will help you decide which material is the most appropriate.

When to replace windows and doors

At some point, repairs may be too costly or time-consuming and replacement may make more sense. But, before you invest in a complete replacement of all components, consider some less-expensive alternatives:

Replacement window sashes. Older, double-hung windows can have new sashes installed that are multiple-paned and tightly sealed. The window frames

remain, and new jamb inserts are installed to accept the somewhat smaller sash units. This approach may not require the removal of interior or exterior trim, and provides an opportunity to seal and insulate all around the unit.

Replacement storm windows and doors. Aging, damaged, or poorly made storm windows and doors can allow air leakage directly onto the main unit, reducing its thermal performance. Replacing the storms can be considerably cheaper than all new windows and can provide good air leak control as well.

Interior window coverings. Although drapes and blinds are important for reducing solar gain during the summer, specially designed interior window coverings are not considered as important for winter energy saving as they were a few years ago. Because they keep much of the warmer room air from the glass surface, condensation from any small air leaks can cause frost buildup, which can lead to component damage.

Interior panels. Sometimes thought of as "inside storms," these consist of glass or acrylic panels that are custom-sized for each window. Some are designed to be installed in the fall and removed in the spring (much like exterior storms) and others have a permanent mount with an operable sash. Because of the considerable risks of condensation and damage to the main window unit and components, proper installation and air-sealing of interior panels is essential.

Interior films. Interior plastic films ("shrink wrap") are an inexpensive way to eliminate air leakage around windows. These products use an easily removable tape to fasten the film to the exterior moulding or sometimes parts of the frame. Installed in the fall and removed in the spring, interior films are very effective and can be installed by most homeowners and renters to reduce air infiltration.

What to look for in new windows

If damaged beyond repair or if there are cosmetic reasons for replacement, it may be time to purchase new windows. Buying windows, however, can be confusing. There are multiple options available, including the materials used in the frames, the finishes, the types and quantities of insulating and sealing materials, coatings, and more. But for evaluating energy efficiency, there are some basic things to look for:

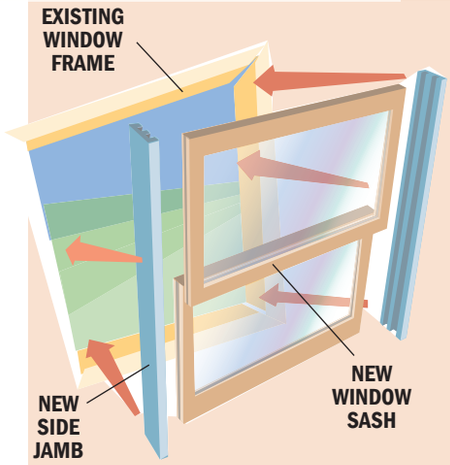
The NFRC label

The first thing you should look for is a label from the National Fenestration Rating Council (NFRC). The NFRC is a nonprofit organization that provides consistent energy and performance ratings of windows, doors, and skylights. It evaluates products according to several categories, including:

- ***U-factor:*** The ability of a window to conduct heat (the inverse of an R-value, used to evaluate products like insulation). U-factor ratings generally fall between 0.20 and 1.20; the lower the number, the better the energy efficiency of the unit. The recommended U-factor for windows is 0.30 or less.
- ***Solar Heat Gain Coefficient:*** Measures a window's ability to reduce heat gain in the summer, thus reducing cooling loads. Based on a zero to 1 scale, a lower number will reduce solar gain. In Minnesota, a good balance of about 0.50 is recommended.

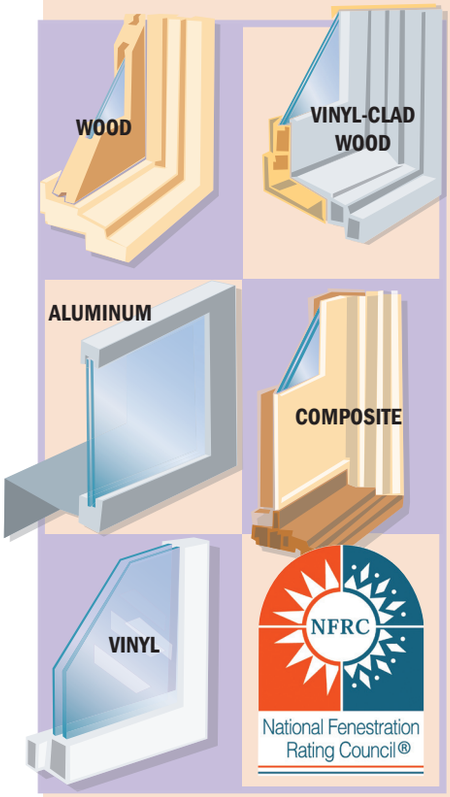
The ENERGY STAR® label

The U.S. Department of Energy and Environmental Protection Agency have developed an ENERGY STAR® designation for products meeting certain energy performance criteria. Since the energy performance of windows, doors, and skylights can vary by climate, product recommendations are given for specific climate zones.



Window repair options

If the basic frame of the window is in good or repairable condition, a jamb and sash replacement may be an economical and efficient choice.



Window replacement options

If new windows are needed, there are several materials and finishes available (above). Check the NFRC label for information about efficiency and performance.

Proper window & door installation is critical to good performance

As with any product, proper installation of doors and windows will provide the best performance. That means suitable insulation and air-sealing between framing and units, and correct flashing on the exterior to prevent water intrusion.

To ensure warranty coverage, manufacturer's instructions must be carefully followed, as well as applicable building and energy code requirements.

Remember, a gain in efficiency can be quickly negated by substandard installation or lack of attention to detail. In other words, buying windows and doors with high thermal performance and durability won't do you much good if they are improperly installed.

Window features

Several features contribute to the ENERGY STAR® and NFRC ratings, including:

- ***Multiple glazings.*** Generally, the more panes of glass (or glazings) the better the insulating quality of the window. Double-paned windows are the standard in new windows; triple-panes in certain applications (large or fixed windows, for example) can improve thermal performance.
- ***Gas filling***. The space between the glazings can be filled with inert gasses (such as argon or krypton) that are better insulators than air.
- ***Low-e coatings.*** Adding a metallic coating to the glass layers can lower the window's ability to transfer heat.
- ***Insulating spacer.*** The material that separates the panes of glass can also conduct heat. Wood or other insulating material is better than metal.

Sash and frame construction

Important to the air leakage and U-factor of a window, the materials that compose the sash and frame also have an effect on maintenance and durability.

- ***Solid steel and aluminum.*** Although durable, these materials are poor insulators and have higher rates of expansion and contraction, making weather-stripping and caulking joints more prone to failure.
- ***Wood.*** A traditional material, wood is a good insulator and has much less expansion and contraction than other materials. However, wood is susceptible to moisture damage and requires more maintenance.
- ***Vinyl.*** Nearly maintenance free and similar to wood in insulating value, vinyl has higher expansion and contraction than wood. It can also be subject to sun damage, peeling, warping, and discoloration.
- ***Fiberglass.*** Offers high insulating, lower expansion, and contraction.
- ***Wood clad.*** A wood frame covered with metal or vinyl offers good insulation and low maintenance, with lower expansion and contraction.

Doors

Of all the parts of a house, doors suffer from a lot of use, especially weather-stripping and thresholds. Although much can be done to extend their life, eventually maintenance and repairs cannot overcome issues such as warping or component deterioration.

What to look for in new doors

Doors, too, offer a wide range of choices for materials, finishes, and insulation. As with windows, the ENERGY STAR® designation and the NFRC label will tell you the energy efficiency of a particular door. U-factor is the most important consideration for doors; a rating of 0.30 or less is recommended. Keep in mind that the more glass area in a door, the lower the thermal performance.

Several features contribute to the ENERGY STAR® and NFRC ratings in doors, including:

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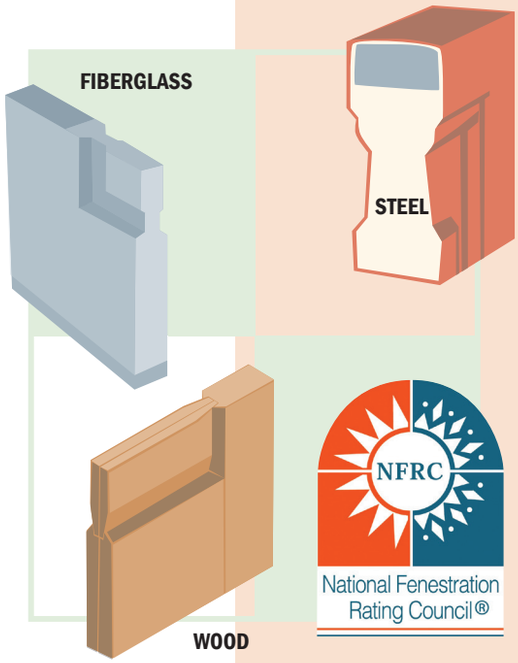
- ***Insulated steel.*** Commonly made with a steel face and filled with polyurethane insulating foam—with a U-factor as low as 0.17—these doors can exceed the energy performance of a wood panel door considerably. They usually come prefinished and prehung in a weather-stripped frame.
- ***Wood.*** Although the traditional wood panel door has the benefits of less expansion and contraction than steel doors, it also has a relatively poor thermal performance (U-factor of about 0.50) and has higher maintenance requirements.
- ***Insulated fiberglass.*** With the thermal advantages of an insulated steel door, fiberglass products usually have a wood-like appearance and are paintable and stainable. In addition, they have less expansion and contraction than steel doors.

Pay attention to the bottoms of doors

The bottoms of doors, unlike jambs, are subject to additional wear and therefore the weather-stripping must be more durable. There are two ways to strip this area: by using a threshold or by attaching a door bottom or sweep. Some thresholds will adjust to accommodate different clearances, but others will not.

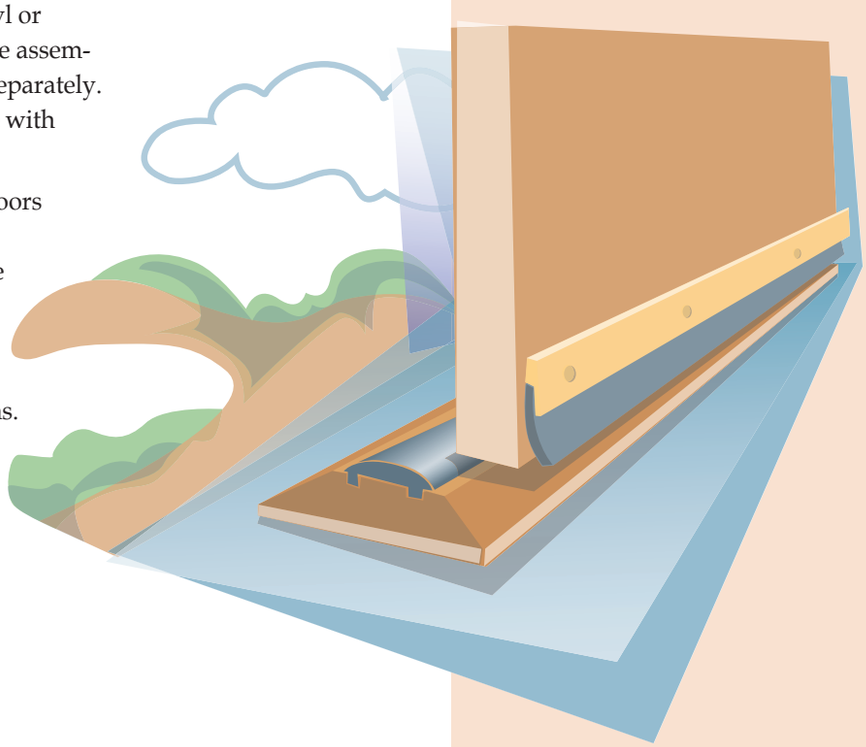
Door sweeps require no clearance, because they attach to the side of the door. Thresholds are generally installed to replace existing worn out ones. Often only the vinyl or rubber weather-stripping is defective, not the entire assembly. Check to see if new inserts can be purchased separately. If the whole threshold must be replaced, select one with replaceable gaskets.

Door bottoms or sweeps are usually installed on doors with no existing bottom weather-stripping. They are installed flush with the floor or threshold of the existing sill to provide a positive seal against air movement. Select a sweep that can be adjusted to compensate for wear or movement due to dimensional changes from temperature fluctuations.



Door replacement options

If new doors are needed, there are several materials and finishes available (above). Check the NFRC label for information about efficiency and performance.



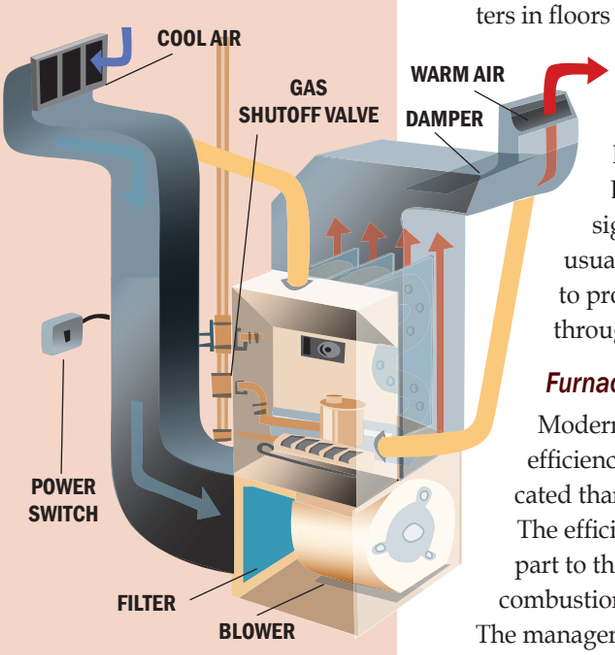
Combustion safety

Three basic things are needed for making heat in a combustion system such as a furnace or boiler: fresh air, fuel, and a pathway for venting.

Older, less efficient systems combine air from inside the building with fuel in the combustion chamber and direct exhaust gasses to a chimney, where it is expelled to the outside.

However, this process can sometimes bring outside air in through cracks and other unsealed openings to replace the exhausted air. When air is pulled back down a chimney opening (backdrafting) it can lead to serious health and safety issues for the occupants. Odorless carbon monoxide and other gasses can cause flu-like symptoms or lead to unconsciousness and death.

Newer high efficiency systems eliminate these concerns through a "sealed combustion" process, which keeps dangerous combustion by-products away from the air in the home and the occupants. Regardless of what type of systems are in use, proper installation and maintenance of carbon monoxide detectors is required.



There are several systems for providing heat to your home, depending primarily on the way heat is distributed throughout the building. Furnaces move heated air through ductwork and into rooms via registers. Boilers heat water and send to room radiators through pipes. Space heaters provide heat to individual rooms. Different fuels provide different advantages and costs.

Furnaces

The most common equipment used for heating homes is a furnace, which heats air and distributes it throughout the home. Furnaces are usually controlled by a single, centrally located thermostat.

Types of furnaces

Furnaces heat air by using electricity or by burning a fuel (usually natural gas, propane, or fuel oil) and then distributing the warmed air to the various rooms in the house.

Forced-air furnaces are the most common type of furnace and blow heated air throughout the house with a fan through a network of ducts and registers. These systems provide the opportunity to control heat levels in individual rooms by operating registers and baffles in the ductwork.

Gravity-fed furnaces heat air which is distributed (without a fan) through registers in floors and walls. Because warm air rises and cool air falls, these systems rely on convection or gravity to distribute the heat throughout the house. Because of the age and design of these systems, they are usually very inefficient and tend to provide uneven temperatures throughout the house.

Furnace repairs & maintenance

Modern furnaces—especially high efficiency models—are more complicated than models from decades ago. The efficiency gains are due in large part to the careful balancing of fuel, combustion air, and exhaust gasses. The management of these systems is accomplished through electronic controls, which need periodic adjustment and cleaning for optimum performance. An annual clean and tune of the furnace will keep the systems properly adjusted, and potentially reduce costly future repairs. A qualified technician should:

- Check igniter and flame sensor
- Pull and clean burners
- Inspect heat exchanger for excess rust or cracks
- Blow out condensate line (90%+ models)
- Check system static pressure
- Do a combustion analysis
- Check gas pressure
- Check for gas or venting leaks
- Inspect and lubricate blower motor

Additionally, there are a few things that homeowners can do to keep their furnace operating efficiently and safely:

- ***Furnace filter replacement.*** A clogged furnace filter reduces the airflow through the system, making the furnace work harder and longer to deliver heat throughout the house. A standard filter (about 1 inch thick) should be replaced monthly, especially under dusty conditions. Larger pleated filters (3-6 inches thick) are designed to remove smaller particles (pet dander, pollen, etc.) and may last several months. It is important to check with the furnace manufacturer to determine what types of filters can be used and how frequently they must be changed.
- ***Condensate line.*** Higher efficiency furnaces condense water as part of the combustion process. There is usually a plastic/rubber drain line (about an

inch in diameter) that leads from the furnace to a nearby drain. If this line becomes plugged, the furnace may not operate properly, and may even shut down. Check the line each time you replace a filter.

- *Air intake and exhaust.* If the furnace cannot get fresh air or exhaust the combustion gasses, it may shut down. Partial blockages can lead to poor performance or dangerous conditions. Inspect plastic pipes that enter or leave the side of the house and ensure there are no insect or animal nests, foliage, or snow blocking the pipes. Furnaces that exhaust through a chimney should be inspected annually for blockages and to ensure the integrity of bricks, mortar, flashing, etc.
- *Adjust thermostat*. Use your programmable thermostat to reduce the operation of the furnace at night and when you are not home.

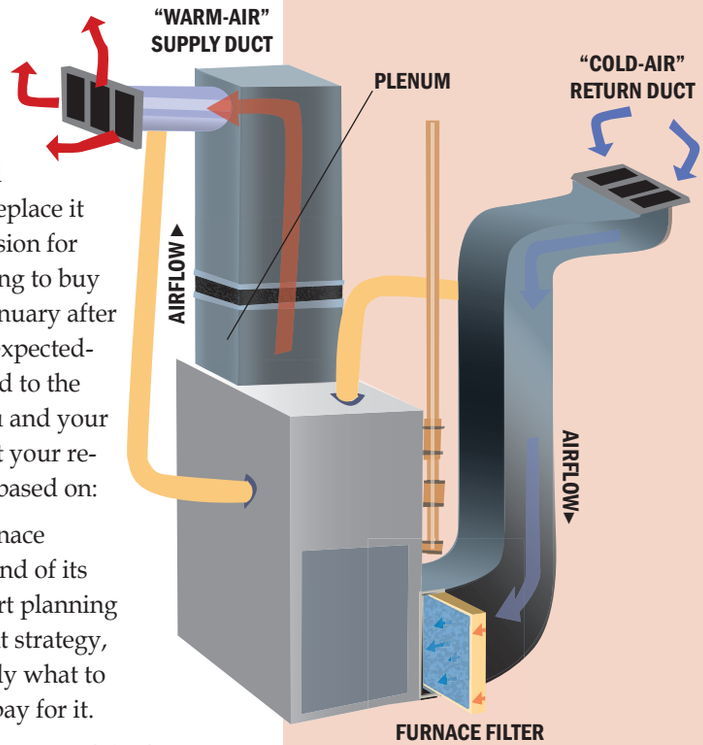
Replacing a furnace

Most furnaces have a useful life of 15-20 years, depending on conditions. Furnaces in buildings that are leaky and poorly insulated will run more frequently than those in tighter homes—and will have a shortened expected life or higher repair costs. Poor maintenance can also cause early failures in furnaces.

When to replace?

A furnace may be the most expensive piece of equipment in most homes, and deciding when to replace it is a significant decision for homeowners. Having to buy a new furnace in January after the old one has unexpectedly died may not lead to the best choices for you and your home. Instead, start your research in advance, based on:

- *Age.* As your furnace approaches the end of its expected life, start planning your replacement strategy, including not only what to buy but how to pay for it.
- *Expensive repairs.* Even if the furnace may have more years of expected life, spending 25% or more of the cost of a new furnace on repairs may be an indication it is time to replace rather than repair.
- *Poor energy efficiency.* Furnaces that deliver 80% AFUE (annual fuel utilization efficiency) or less efficiency are costing you real dollars in fuel use. An increase in efficiency to 95% may easily pay for itself during the life of the new furnace.



Furnace filters

The furnace filter is located between the return duct (sometimes called "cold-air return") and the furnace. The air is returning to the furnace from throughout the house, where it will be heated and redistributed through the supply duct.

Furnace filters have an arrow that indicates airflow direction; make sure it is aligned with the direction that air is flowing from the return duct into the furnace.

Some systems have a filter cover which covers the access to the filter. Be sure that it is sealed tightly to prevent air leaks. If there is no filter cover, seal with metal foil tape.

Furnace efficiency savings: an example

Calculators (available online) can help determine potential energy savings between different furnace efficiency standards. The following example was based on a calculator from the Center for Energy and Environment (mncee.org) .

Assumptions. The example included these basic characteristics of a sample home; your numbers may be different:

- Located in Twin Cities metro
- Built between 1960-1969
- Square footage between 2,500-3,000
- Comparison between 80% and 95% AFUE natural gas furnaces
- Gas cost of $0.77/therm

Results. These are the annualized numbers from the calculator:

Efficiency:	80%	95%	Savings
Therms:	2,396	2,017	379
Dollars:	$1,844	$1,553	$291
CO2 Lbs. :	26,520	22,340	4,180

In this example, a savings of nearly $300 a year (at present costs) translates into $4,500 over a 15+year estimated life of the furnace—enough to cover the additional cost of the more efficient furnace several times over.

The dangers of CO

When the by-products of combustion are not properly vented to the outside, it can lead to unhealthy conditions. Among the most dangerous components is carbon monoxide (CO), an odorless, invisible gas that causes illness—and sometimes death—among many Minnesotans every year.

What to look for

The symptoms of CO poisoning are easily confused with those of a flu or cold: headache, nausea, irritated eyes and nose, and—eventually—confusion and lethargy. The physical symptoms may lessen when away from the home. Another clue is moisture build-up in the house, especially condensation on cooler windows.

Causes

There are several possible causes of CO in a home, but many have to do with problems with the proper venting of flue gasses:

- Cracked furnace heat exchanger
- Blocked or undersized chimney or vents
- Damaged or separated vents
- Insufficient combustion air supply

Preventing CO in your home

These two recommendations will help keep your family safe:

- Install code-required CO detectors near all combustion devices and within 10 feet of all bedrooms
- Have annual inspections with a CO test of all combustion devices (furnace, water heater, fireplace, dryer, range)

What to look for in a new furnace

There are several things to consider when shopping for a new furnace:

Efficiency

Higher efficiency furnaces will provide ongoing benefits including lower energy bills and reduced environmental emissions. Going from an 80% efficient furnace to a 95% efficient model could save several hundred dollars a year in fuel costs (depending on many factors). Some furnaces can deliver over 98% efficiency.

Proper sizing

A common concern when purchasing a new furnace is determining the proper size for a given home. Be wary of being sold a unit that is larger than what was there previously—oversized furnaces cycle more frequently, causing extra wear and actually lowering the comfort level—and will be more expensive to purchase. Also avoid automatically installing the same size furnace as what is being replaced—especially if significant improvements to the building (additional insulation, air-sealing, new windows) have been implemented since the old furnace was first installed. The building code requires a heat-loss calculation based on the size of the house, the insulation levels, the number windows, previous energy bills, etc. Insist on a heat-loss calculation worksheet as part of any contract.

Ductwork sizing

New high efficiency furnaces typically move air at a higher speed than older, less efficient furnaces. To ensure the furnace will run at its highest efficiency, the ductwork must be properly sized for the furnace. Properly sized ductwork reduces the pressure on the blower motor (increasing its life) and improves comfort in the home. Whenever a new furnace is installed, the ductwork (including baffles and registers) should be examined to make sure airflow is not restricted.

Blower motor

The blower motor operates the fan that distributes heat throughout the home. Older furnaces typically had one speed that would come on as soon as the thermostat called for heat and run until the furnace was cold. Significant advancements have been made in the past few years in blower motor design and operation, improving efficiency and comfort. Variable speed motors (controlled electronically) automatically adjust the flow of the blower motor to changing conditions and use up to 60% less electricity. They also increase comfort by reducing the rush of cold air at the beginning and end of the cycle.

Another option when reviewing blower motors is to add electronically commutated motors or ECM motors. These motors are more efficient than a variable speed blower motor and can reduce fan noise considerably.

Sealed combustion

New high efficiency furnaces no longer take room air for combustion or allow exhaust gasses to rise naturally up a chimney. A sealed combustion furnace keeps the airflow of combustion completely separated from the interior air of the house. This accomplishes several things essential to the safety and efficiency of the furnace:

- ***No backdrafting.*** Fresh air is drawn in through a plastic PVC pipe, delivered to the combustion chamber where the fuel is burned, and the exhaust gasses are vented directly to the outside through a similar plastic PVC pipe with the aid of a fan. As the connections in this system are tightly sealed, the dangers of backdrafting as a result of the operation of the furnace are essentially eliminated.
- ***Increased efficiency.*** Because the airflow to and from the furnace can be tightly controlled, the ability to provide maximum efficiency in the combustion process is enhanced.

- ***Lower flue gas temperatures.*** Because more heat is being extracted from the combustion process (through a secondary condensing heat exchanger), less heat is going out the exhaust. This lowers the flue gas temperature, allowing it to be vented through the PVC piping. This lower temperature also reduces risks associated with hotter flue gasses.

Additionally, high efficiency furnaces use electronic ignition (rather than a pilot flame) to ignite the fuel. Further electronics manage the air/fuel mixture and ensure efficient and safe operation under a wide range of conditions.

Boilers

Boilers heat water—in a closed-loop system—and distribute it throughout the house. Next to furnaces, boilers are the second-most common method of heating homes. Many hot water boiler systems can also provide domestic hot water for bathing, washing, etc. along with heating the house.

How a boiler works

Boilers heat water by using electricity or by burning a fuel—natural gas, propane, fuel oil, or wood are the most common. The heated water is then distributed through the house in a variety of ways:

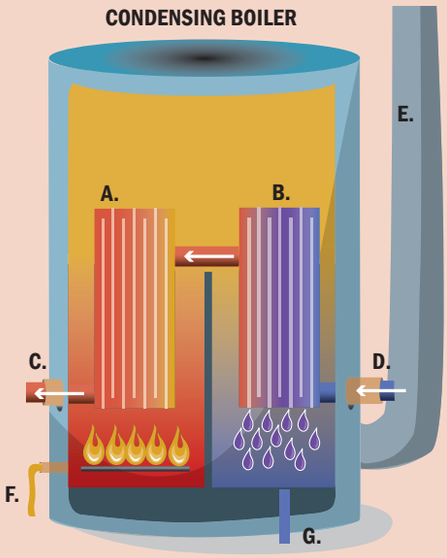
- ***Hot water radiator*** systems for home heating are typically found in older homes. Heated water is distributed through pipes to large cast iron radiator units throughout the house. Radiators absorb the heat from the water and then radiate it back to the room over time. Although some systems provide options for regulating the heat output of individual radiators, many older systems rely on a single centrally located thermostat to control the temperature in the house.
- ***Hot water baseboard*** systems are more common than radiator systems and provide heat to rooms through smaller units located at the "base" of walls. They consist of copper pipes with fin tubes that heat the surrounding air, providing convective heat for the room.
- ***In-floor hot water*** systems distribute heated water through a series of tubes embedded in a concrete slab or between floor joists. In-floor systems are often controlled by valves that divide the home into zones; they can provide a steady heat source but can be slower to respond to changes in heating requirements. Some hot water systems use tubes embedded in walls, but these usually don't have the thermal storage capacity of an in-floor system.
- ***Hydronic air handlers*** send heated water through a coil located in the ductwork of a forced-air distribution system; an air handler or fan distributes heated air through the ductwork.

Boiler repairs & maintenance

Boilers can provide good efficiency and performance for many years if maintained and tuned. Even older boilers can operate at 70% to 74% efficiency when properly operating—although this is considerably less efficient than newer models (80%-98%).

Boilers should be inspected on an annual basis and adjusted as needed to meet the manufacturer's specifications in order to maintain both efficiency and safety. The following items are services that a qualified service technician should do:

- Check the combustion chamber for cracks.
- Test for levels of carbon monoxide in the flue.
- Check the water pressure gauge setting and adjust as needed.



Condensing Boiler

A. hot combustion gas

B. cooling combustion gas

C. hot water flow

D. return flow

E. flue

F. gas line

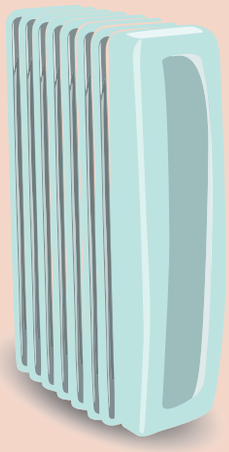
G. condensate drain

Fuel sources

Furnaces and boilers can be fueled by petroleum products, electricity, biomass, the sun, or a combination.

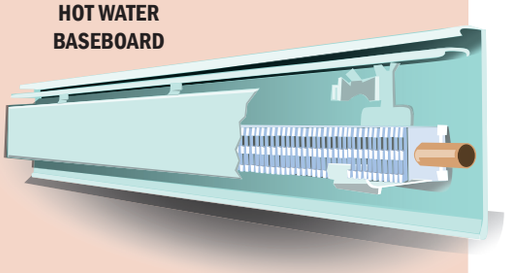
Although often based on the local availability of specific fuels, there can be many reasons to choose one fuel over another, including the cost per BTU, the environmental effects, the installation cost, and the lifetime operating costs (including maintenance, repair, and eventual replacement).

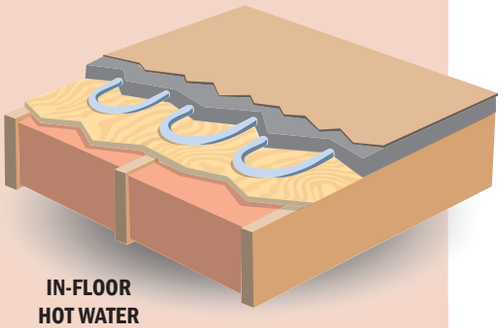
When switching from one fuel source to another, be sure you have carefully considered all the factors.



HOT WATER RADIATOR

HOT WATER BASEBOARD





IN-FLOOR HOT WATER

HYDRONIC AIR HANDLERS

- Test the high-limit control.
- Lubricate circulator pumps.
- Inspect the pressure tank and drain if necessary.
- Bleed air from radiators and baseboard convectors.
- Remove dirt, soot, or corrosion from the boiler.
- Vacuum and clean the fin-tube convectors and radiators.

Replacing a boiler

Most boilers have a useful life of 20-30 years, depending on conditions. Boilers in buildings that are leaky and poorly insulated will run more frequently than those in tighter homes—and will have a shortened expected life or higher repair costs. Other circumstances (including poor maintenance) can cause early failures in boilers.

When to replace?

As with a furnace, the boiler may be the most expensive piece of equipment in a home, and deciding when to replace it is a significant decision for homeowners. To avoid a surprise replacement, do your research in advance, based on:

- ***Age.*** As your boiler approaches the end of its expected life, start planning your replacement strategy.
- ***Expensive repairs.*** Even if the boiler may have more years of expected life, spending 25% or more of the cost of a new boiler on repairs may indicate replacement rather than repair.
- ***Poor energy efficiency.*** Boilers that deliver 70% AFUE (annual fuel utilization efficiency) or less efficiency are costing you real dollars in fuel use. An increase in efficiency may easily pay for itself during the life of the new boiler.

What to look for in a new boiler

There are several things to consider when shopping for a new boiler:

Efficiency

Higher efficiency boilers will provide ongoing benefits, including lower energy bills and reduced environmental emissions. The minimum AFUE rating for a gas-fired hot water boiler is 82% and for an oil-fired hot water boiler is 84%.

Going from a 70% efficient boiler to a 98% efficient one could save significant dollars in fuel costs and the attendant environmental costs of using the fuel.

High efficiency gas-fired boilers cannot have a constant burning pilot, and must have an automatic means for adjusting the water temperature to match the heating load.

Proper sizing

It is important to determine the proper size of a new boiler for a given home. Be wary of being sold a unit that is larger than the previous boiler—oversized boilers cycle more frequently, causing extra wear and actually lowering the comfort level—and will be more expensive to purchase. If significant improvements to the building (additional insulation, air-sealing, new windows) have been made, a smaller boiler might be appropriate. The building code requires a heat-loss calculation based on the size of the house, the insulation levels, the number windows, previous energy bills, etc. Insist on a heat-loss calculation worksheet as part of any contract.

Sealed combustion

New high efficiency boilers no longer take room air for combustion or allow exhaust gasses to rise naturally up a chimney. A sealed combustion boiler keeps the airflow of combustion completely separated from the interior air of the house. This accomplishes several things essential to the safety and efficiency of the boiler:

- ***No backdrafting.*** Fresh air is drawn in through a plastic PVC pipe and delivered to the combustion

chamber; the fuel is burned and the exhaust gasses are vented directly to the outside through a similar plastic PVC pipe with the aid of a fan. As the connections in this system are tightly sealed, the dangers of backdrafting as a result of the operation of the boiler are essentially eliminated.

- ***Increased efficiency.*** Because the airflow to and from the boiler can be tightly controlled, the ability to provide maximum efficiency in the combustion process is enhanced.
- ***Lower flue gas temperatures***. Because more heat is being extracted from the combustion process (through a secondary condensing heat exchanger), less heat is going out the exhaust. This lowers the flue gas temperature, allowing it to be vented through the PVC piping. This lower temperature also reduces risks associated with hotter flue gasses.

Additionally, high efficiency boilers use electronic ignition (rather than a pilot flame) to initiate combustion. Further electronics manage the air/fuel mixture and ensure efficient and safe operation under a wide range of conditions.

When it comes time to replace a boiler it must be matched to the distribution system. A sealed combustion boiler, for example, may not operate efficiently with radiators. In some cases, a higher efficiency boiler may also require an upgraded distribution system.

Electric heating systems

Electric heating is any process in which electrical energy is converted to heat, including resistance and radiant electric systems:

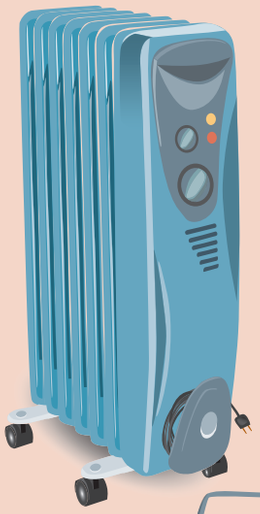
- ***Baseboard convectors*** are a common way to distribute supplemental heat into areas that don't receive sufficient heat from the primary system, such as basements. Directly connected into the house's wiring system, baseboard convectors are inexpensive to install. They are usually controlled with a thermostat on the unit or on a nearby wall.
- ***Electric furnaces*** use an electric resistance coil located in the ductwork of a forced-air system. Because it can share the fan and ductwork, this type of system is compatible with central air conditioning units. Some models can also accommodate thermal storage devices, to take advantage of off-peak electric savings programs.
- ***Electric plenum heaters*** are typically used in combination with a gas- or oil-fired forced-air furnace system. They are usually installed to supplement a more costly or less available delivered fuel source, also to take advantage of off-peak electric savings programs. Installed in the furnace plenum or main trunk line of the ductwork, it uses the existing furnace fan to move air through the ducting system. Although a plenum heater and the furnace often use the same thermostat controls, they can also be controlled separately, allowing for independent fuel selections.
- ***Radiant electric heating*** consists of cables that are typically installed in floors, although they can be used in ceilings or wall panels as well. When installed in a floor, the cables usually heat a thermal mass (such as concrete or tile) which then transfers the heat slowly to the room over time. In-floor systems with thermal mass storage can also take advantage of off-peak electric rates to reduce operating costs. Wall or ceiling panels operate on the thermal principle of radiance, and the cables emit infrared rays that warm bodies more than the air or other things in a room. Electric radiant heating is most easily installed during new construction or major remodeling and is appropriate for energy-saving zoned heating.

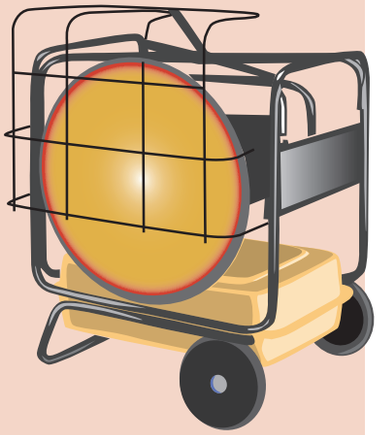
How efficient is electric heat?

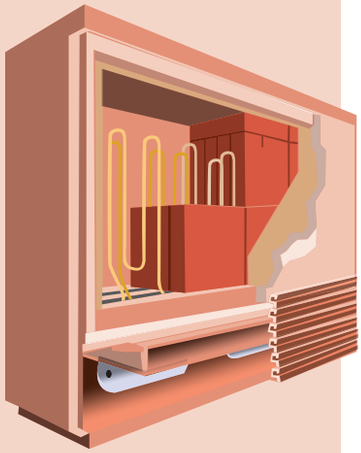
The efficiency of electric heating is 100% because all the purchased energy is converted to heat—there are no heat losses that go up the chimney or out of the vent pipes. (An exception are those electric heaters that are located outside the living space, such as attics or porches. These will lose some heat to the surrounding air, thus reducing their effective efficiency.)

However, if the generation and distribution of the electricity is considered, the overall efficiency drops. When compared with other fuels used for home heating, electricity use also contributes more CO_2 to the environment per BTU and—depending on current costs—can cost more per BTU.

In locations with limited home heating options, electric heat can be a good choice. Installing zoning and taking advantage of less expensive off-peak usage can make electric heating cost-effective.







Electric heating repairs & maintenance

Because there are few moving parts, most electric systems have a very long expected lifetime. As with combustion furnaces, electric furnaces require similar maintenance regarding filters and other controls. Other potential problems may occur with zoning switches or thermostats, remedied by cleaning and replacement as needed. Occasionally, breaks in lines or circuits can occur, due to floor or wall movement or other construction projects. These may require an electrician to isolate and repair or replace damaged sections. In the case of cable buried in concrete, repair costs may be prohibitive.

Space heating

Space heating refers to equipment that provides heat to a small space, usually a room. This equipment is usually portable but may include fixed installations, such as fireplaces.

- ***Unvented combustion space heaters*** that use fuels such as kerosene, heating oil, propane, charcoal, white gas, or anything else that burns are ***extremely dangerous and illegal to use in a confined space!*** The risks include carbon monoxide poisoning, as well as potential fire hazards. Many of these devices were sold years ago, before there was a complete understanding of the dangers—and before we began to tighten our homes with insulation, air-sealing, and new windows and doors. Even unvented units used in attached garages are unsafe, due to the potential of gasses leaking into the home.
- ***Vented combustion space heaters*** include units such as gas or wood fireplaces and gas/oil/wood stoves. Because they are vented to the outside, these devices are not portable and require a fixed location in a room. Some units are designed to be vented out through a special panel inserted into an open window. As with all combustion devices, proper installation, venting, fuel supply, and spacing from walls and furniture are essential for safe operation. In insulated and sealed homes, these devices will likely require a fresh air supply to operate properly and safely.
- ***Electric space heaters*** are the most common type of space heating. Consisting of a floor unit plugged into a wall outlet, these can be of several types, including radiant heaters, oil-filled heaters, and heaters with circulation fans to distribute the air throughout the room. Newer models have automatic shut-off switches in the event they are tipped over.

Wood and biomass systems

Before the 20th century, 90% of Americans burned wood to heat their homes. As fossil fuel use rose, the percentage of homes using wood for fuel dropped, falling to less than 1% of all households by 1970. During the energy crises of the 1970s, interest in wood and biomass heating resurfaced as a renewable energy option.

That interest has slowly grown (about 2% of Minnesota households now heat with wood or biomass products) and a whole new generation of wood- and pellet-burning appliances is available today.

Wood and biomass systems can be either space heaters (such as fireplaces or stand-alone stoves) or they can provide the fuel for furnaces or boilers for central heating.

Fireplaces

Traditional fireplaces draw as much as 300 cubic feet per minute of heated room air for combustion, and send it straight up the chimney. Although some fireplaces can be fitted with dedicated air supplies, glass doors, and heat recovery systems, wood fireplaces are nearly always net energy losers—especially at the end of a burn cycle when very little heat is being generated.

Only high efficiency fireplace inserts increase the heating efficiency of older fireplaces. The inserts function like wood stoves, fitting into the masonry fireplace and using the existing chimney. Proper

installation of fireplace inserts is very important to increase efficiency and reduce risks associated with chimney failures.

Wood stoves

A step up in efficiency from a traditional fireplace, modern wood stoves offer many features that increase safety and efficiency. Catalytic wood stoves may have efficiencies of 70%–80%, for example.

Catalytic stoves burn both combustible gasses and the wood particulates before they exit the chimney. The design has a metal channel that heats secondary air and feeds it into the stove above the fire. This heated oxygen helps burn the volatile gasses above the flames without slowing down combustion. However, the advanced combustion design only works efficiently when the wood fire burns very hot—upwards to 1,100 degrees F.

Wood stoves, air pollution and building codes

Wood-burning appliances and fireplaces can produce large quantities of air pollutants. Wood smoke contains nitrogen oxides, carbon monoxide, organic gasses, and particulate matter, each of which has serious health effects, especially to those who have compromised respiratory conditions.

Some cities restrict wood heating appliances when local air quality becomes unhealthy. Others restrict or ban the installation of wood-burning appliances in new construction.

Before installing a wood- or pellet-burning system, contact your local building codes department about regulations that may apply in your area.

Pellet fuel appliances

Pellet fuel appliances burn small pellets (less than 1 inch) that are made from compacted sawdust, wood chips, bark, agricultural crop waste, and other organic materials. They have a much higher combustion and heating efficiency than ordinary wood stoves or fireplaces and produce very little air pollution. In fact, pellet stoves are the cleanest of all solid fuel-burning residential heating appliances. They are also exempt from United States Environmental Protection Agency (EPA) smoke-emission testing requirements.

Many pellet burners can be direct-vented and do not need an expensive chimney or flue. They are available as freestanding stoves, fireplace inserts, or pellet-fired furnaces and boilers.

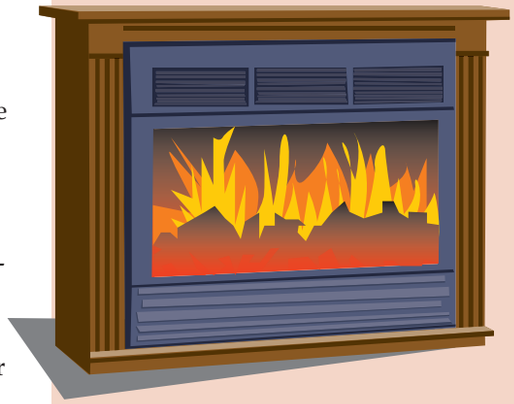
All pellet fuel appliances have a hopper to store the pellets until they are needed for burning. Most hold enough fuel to last a day or more under normal operating conditions. A feeder device, like a large screw, drops a few pellets at a time into the combustion chamber for burning. Advanced models have a small computer and thermostat to govern the pellet feed rate.

Pellet appliance exteriors stay relatively cool while operating and, because they burn fuel so completely, very little creosote builds up in the flue and there is less of a fire hazard.

Maintenance of wood and biomass systems

Newer wood- or pellet-burning systems are efficient if regularly maintained. Before each heating season have a chimney sweep (certified by the Chimney Safety Institute of America) inspect your wood-burning system. A certified chimney sweep will help make sure your appliance, hearth, connecting pipe, air inlets, chimney, and all other components are functioning efficiently and safely.

Catalytic combustors need to be inspected at least three times every heating season and replaced according to the manufacturer's recommendations. Most catalytic stoves or inserts have a view window or thermometer to help you check the combustor.



Heat your house with electric fireplaces?

In the rush to save energy, some people assume that space heaters are a better option than furnaces or boilers for heating their homes.

In fact, most of these devices are far less energy efficient than whole-house heating systems, given that they often do a poor job of distributing heated air. That poor distribution requires higher temperatures—and thus more energy use—to achieve the desired heat levels.

However, they can reduce overall energy use, if the whole-house system is turned down very low and the space heating is only used in occupied, closed rooms.

Many people also confuse aesthetic features with functional and efficiency related features. Wood mantels and attractive cases do not increase efficiency or improve heat circulation—and they often come at a very high price. A 1,500 watt, $45 "milk-house" electric space heater will produce the same amount of heat at the same efficiency as a 1,500 watt, $450 electric fireplace. Be certain what you are investing in has worthwhile features, including efficiency, safety, and comfort.

Cleaning out the inside of the appliance with a wire brush periodically will also help your wood-burning appliance heat your home efficiently. Even a one-tenth inch of soot can drop the heat transfer efficiency of the metal by 50%.

Access and storage of biomass fuels

Before purchasing any type of wood or pellet heating system, ensure that you will have long-term access to the fuels and that you have considered the costs of delivery and storage—including protection from weather.

Additionally, determine if your municipality has any restrictions for on-site storage of wood or pellets. Some cities prohibit the transport or storage of wood products that might harbor damaging insects or disease.

Solar heating

There are two basic ways we can use the sun to heat our homes:

- Through passive design that allows sunlight to enter through windows and warm the contents passively;
- Through active roof- or wall-mounted panels that allow the sun to heat a medium (air or water) which is then distributed through the house.

Passive solar design

The components of designing a building to take advantage of the sun have been around as long as there have been structures that people have built. A simple orientation to allow sunlight to enter passively through windows provided not only illumination but additional heat from the sun's rays.

Today we blend the heat transmitting properties of windows with the heat absorbing capabilities of interior materials and structures, usually as part of new construction or major remodeling projects. A well designed passive approach can supply sufficient solar heat gain to provide a significant portion of the heat load—especially when coupled with high levels of insulation and air-sealing. Often, passive design requires minimal additional costs, especially at early stages of the design process.

Passive solar design includes several elements:

- ***Large south-facing windows*** that gather sunlight from the low sun angles that occur during the heating season. These windows often have a somewhat higher solar heat gain coefficient to allow more solar gain in the winter.
- ***Roof overhangs, awnings***, or other devices that provide shading from the higher-angled summer sun, thus reducing cooling loads in warmer seasons.
- ***Thermal storage*** capabilities that allows the heat from the sun to be absorbed and emitted slowly during the evening hours. These structures may include masonry walls and floors, although they must be carefully designed and sized to maximize the heat transfer process.

Active solar heating

Active solar heating systems (solar thermal) require collectors, pumps, fans, ducts, or piping to absorb and distribute the heat gathered from the sun. There are two basic types of active solar systems which can provide supplemental heat to a building: liquid- and air-based systems.

Liquid systems use the sun's energy to heat a liquid (usually an antifreeze/water mix) in a collector that is mounted on the south-facing roof of a building. As the liquid is warmed, it is pumped to an insulated storage unit where an exchanger distributes heat through the system: hot water baseboard, in-floor, radiator, or forced-air furnace.

Air systems use a collector (often mounted on the exterior of a south-facing wall) to collect air heated by the sun. A small, thermostatically controlled fan takes warm air from the collector and sends it through a duct and into the building; a

Renewable readiness

Sometimes the timing or cost of a construction project does not permit the immediate installation of an active solar system. Nonetheless, a small investment in planning can reduce the costs of a later addition of a solar installation.

Orientation and angle of roofs should be optimized for the placement of future panels. Additionally, ensure that roof trusses and other structural components are designed to accommodate both the dead load of panels and the loads associated with winds and snow.

Interior chases to accommodate future piping and wiring should be built before walls are finished. These chases should run from attic to basement and be insulated and sealed.

return duct brings cooler air into the panel to be heated. Air systems are usually used to provide supplemental heat for a room or section of a house, rather than being tied into the main heating distribution system.

Siting and sizing a system

Proper siting will maximize the amount of energy collected. A solar site assessment can determine feasibility and proper locations for solar. A qualified solar installer will properly size and site a solar thermal system and provide ongoing system maintenance.

Heat pumps

Electric heat pumps (which use a compressor similar to a refrigerator) extract heat from a "sink"—usually either the ground or air. The captured heat is distributed with a heat exchanger through existing distribution systems. In summertime this cycle can be reversed to provide cooling.

Air source heat pumps

Air source heat pumps (ASHP) can extract heat from outdoor air in warmer climates; sub-freezing temperatures reduce the efficiency of most systems, requiring backup heating in our Minnesota climate. Some newer designs can provide heat at lower outside temperatures, but installation and operation costs should be carefully compared with other available fuel sources and systems for heating. Air source heat pumps can also provide a good cooling option, especially in homes without ductwork.

Ground source heat pumps

Ground source heat pumps (GSHP) are used for space heating and cooling; some systems also provide domestic hot water heating.

As with air source heat pumps, GSHP systems rely on a compressor to extract or expel heat with a "sink"—in this case the ground. The part of the system in contact with the ground is called the "loop" and it is most commonly used in two forms: vertical and horizontal loop fields. Larger structures such as commercial buildings and schools often use vertical systems because there is insufficient land available for a horizontal loop system to provide enough heating and cooling for the building.

Horizontal trench installations are more common for residential installations, particularly for new construction or where sufficient land is available. It requires trenches at least 6 to 12 feet deep depending on soil type and climate zone.

When is GSHP the right choice?

The decision to choose GSHP for heating and cooling a building can be challenging, as there are many variables to consider when designing an efficient and affordable system. As with all heating and cooling systems, there are circumstances that provide optimal performance for GSHP systems: large building, high cooling load, southern climate, fine soils, available land, and efficiently designed building. As these ideal conditions decrease the expected performance will also decrease, and installation, operation, and maintenance costs may rise—requiring adjustments in payback calculations.

Are GSHPs "renewable?"

Heat pumps are powered by electricity and are as renewable as the source of the electricity that powers them. Grid-source electricity in Minnesota is about 10-15% renewable, depending on the time of year and other factors. Additionally, any heating or cooling backup systems are also only as renewable as the fuel sources. The carbon load of available fuels should be considered when calculating environmental impacts.

The best way to ensure GSHPs are renewable is to include a solar PV installation to provide the offset electricity required to operate the system.

SOLAR liquid

A. solar collector

B. controller

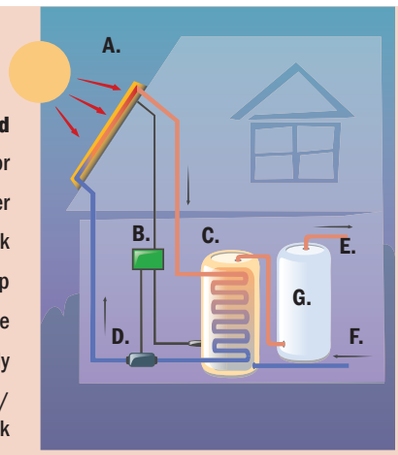
C. exchanger tank

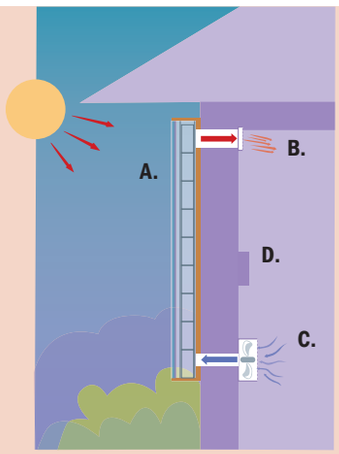
D. pump

E. to infloor / furnace

F. cold water supply

G. water heater / storage tank





SOLAR air

A. solar collector

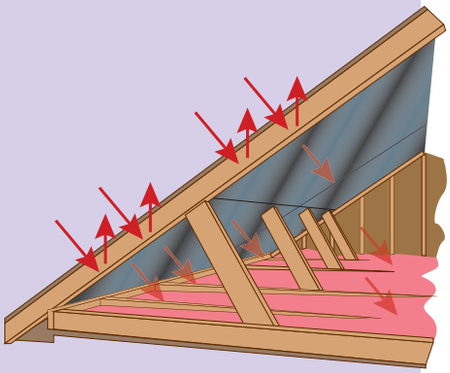
B. warmed air

C. cool air

D. thermostat

Reducing solar heat

Awnings, sunscreens, and trees can reduce solar heat gain in the summer.



Radiant barriers

Do they reduce your energy bills or just reduce your wallet?

Radiant barriers consist of a reflective film, usually aluminum, laid over the top of attic insulation or stapled to the underside of roof rafters in existing homes. They are sold as an energy-saving product, with claims of significant reductions in both heating and cooling costs. However, their potential benefit is primarily in reducing air conditioning loads in warm or hot climates and in buildings with little or no insulation.

Radiant barriers make no sense in Minnesota, as it is not considered to be a hot climate state. In fact, the potential savings on air conditioning in a typical Minnesota home would provide a payback of nearly 100 years!

It is far more effective (and usually cheaper!) to install adequate insulation along with proper air-sealing.

Keeping our homes comfortable in the summer months is nearly as important as in the winter. Although Minnesota historically averages about 12 days a year of 90-degree or warmer weather, there have been increasing numbers of hot days and a significant number of days with high heat index numbers. As these extreme weather events continue, the health and safety issues for the elderly, the very young, and ill people make home cooling more important—and an increasing part of home energy costs.

Reducing heat in your home

There are several things you can do to reduce the amount of heat that enters your home, to reduce the amount of heat you generate inside your home, and to expel the heat that is inside.

Solar heat gain

Although gaining heat from the sun is welcome in the winter, the summer sun adds a significant amount of solar heat gain, because the sun is higher in the sky and there are more daylight hours. There are several things that can be done to minimize the summer sun's heating effects on your house:

- ***Window awnings.*** Made of rigid aluminum or flexible materials such as canvas, window awnings over the south-facing windows can reduce the amount of heat that is transmitted through the glass. East- and west-facing windows can also benefit. The connection between the house and awning must not allow water to pool or leak into the siding or window unit.
- ***Sunscreens.*** Sometimes made of louvered wood slats or panels, sunscreens can be mounted over a window (similar to an awning) or placed over windows (such as shutters).
- ***Trees.*** Properly placed trees can provide cooling shade for both the yard and house, but it can take many years to realize the full benefits. Plant deciduous trees on the west side, at least 20 feet from the house to avoid future foundation or limb issues.
- ***Wide overhangs.*** When building a new home, addition, or a major remodeling that includes roof design, consider adding wide overhangs on the south side to shield the house and windows from the high, hot summer sun. The proper amount of overhang will allow for winter sun to enter and provide solar gain in the cold months.

Keeping the heat out

The same strategies that keep our homes warm in the winter work to keep heat out in the summer:

- ***Insulation.*** Adequate insulation in the attic and walls greatly reduces the flow of heat into your home in the summer.
- ***Air-sealing.*** Whether your home has gaps around vents in the attic or poor weather-stripping of doors and windows, reducing the flow of air into your house will also reduce the heat transfer.
- ***Close windows and doors.*** Whenever it is warmer outside than inside, close all windows and doors and latch them tightly to reduce heat gain.

Reduce indoor heat

Many of our daily activities produce heat or moisture inside our homes. A few changes can reduce the temperature and humidity levels, adding to comfort and saving on air conditioning:

- ***Reschedule.*** Plan to use appliances such as ovens, clothes dryers, and dishwashers in the evening, when it is cooler. These devices can give off a lot of heat into the house when they operate, adding to the cooling load and potentially decreasing comfort.

- ***Turn it off.*** Make sure that any unneeded devices or lighting (especially incandescent!) are turned off or unplugged. Computers, TVs, gaming devices—anything that uses electricity—adds heat to your home.
- ***Properly ventilate.*** When cooking or bathing, use exhaust fans to quickly remove heat and moisture.
- ***Let in cooler air.*** During the cool evenings, a window open on a lower level will draw cool air in; an open window higher will allow heated air to escape.
  - This practice should only be followed if you are *not* using air conditioning systems. Studies have shown that it actually uses less energy to set the thermostat to a certain temperature and keep the air conditioning system on rather than shutting it off and opening windows. This is due to the dehumidification that an air conditioning system provides.

Fans: the first line of cooling

Often misused, fans are one of the most economical ways to cool the most important thing in your house: **you**. Just as with windchill in the winter, moving air will quickly reduce our skin temperature, especially when the evaporation of perspiration is included. Even homes that use air conditioning can benefit from the use of fans. Cooling our bodies with a fan means we can turn up the temperature for the air conditioner, and save energy overall.

Portable fans

Small portable fans can be a very good option for cooling people. Available with either floor stands or table stands, most have several speeds and the ability to oscillate. Some newer designs include fans with concealed blades, which provide high velocity air streams.

Old fans can be dangerous

Many older fans have metal blades and limited shrouds (the screens that keep things from being hit by the turning blades). These can be very dangerous for children and pets; they can also cause problems if they tip. In addition, most older fans are usually very energy inefficient.

Box or window fans

Designed to rest in the opening of a double-hung window, box or window fans can also can serve as portable fans with a supporting base. They can be an efficient way move cooler air into a house from the outside.

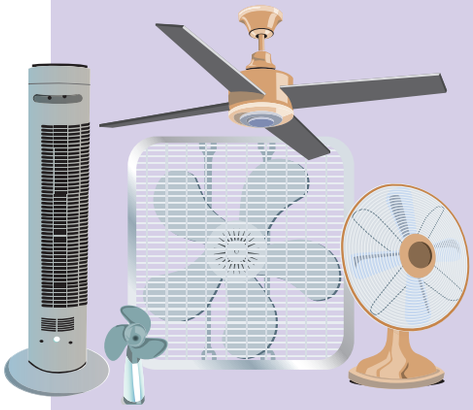
Risks with box fans

If a box fan tips and lies flat on the floor, the airflow can be restricted, which can lead to overheating of the electric motor and become a potential fire risk. Likewise, drapes, curtains, or other things that might obstruct the airflow might contribute to the overheating of the motor.

Box fans placed in a window opening should *only blow in!* Although it might make some sense to have a fan blowing out a window on a higher floor to "suck out the heat," this can depressurize a house, leading to dangerous backdrafting. As air is pushed out of a house, it is replaced through any available opening—which could be the chimney for the water heater or exhaust fans. In certain conditions this can lead to carbon monoxide or other flue gasses building up in the house.

Ceiling fans

A ceiling fan is quieter than a portable fan and is safely out of the reach of children. As with other fans, ceiling fans serve to cool our bodies—not the room. Designed to replace an existing ceiling light fixture, some fans include a light. Ceiling fans should have multiple speed settings and be reversible, to provide the right amount of cooling for the conditions and occupants. Many also have remote controls.



When a fan spins and nobody is there, is it cooling?

Fans cool people. Fans don't significantly cool rooms, furniture, or walls.

Moving air cools us by removing our body heat from our skin (think windchill). This process is enhanced through the evaporation of sweat from our skin.

There are only two times that fans can actually cool a room:

- Removing excess heat and moisture through bathroom or kitchen fans.
- Moving cooler air into a room, either through an air conditioning system or by moving cooler outside air into the house.

The bottom line: A turning fan in an unoccupied space is doing only one thing—using electricity.

Sizing of ceiling fans

Proper sizing of a ceiling fan will provide the most efficient cooling for the occupants of a given room. Use these guidelines when purchasing (and don't forget to look for the ENERGY STAR® label):

Room Size	Fan Diameter
100 ft^2	36"
150 ft^2	42"
225 ft^2	48"
375 ft^2	52"
400+ ft^2	2 or more fans

Whole-house fans

These are *not recommended* in our climate. Cutting a large hole in the ceiling to install a whole house fan creates potential air leaks and a source of heat loss in the winter, since it is very hard to seal and insulate around the fan. Whole-house fans may also depressurize your house, leading to dangerous backdrafting of combustion appliances like water heaters.

Attic fans

Attic fans move air into and through the space in your attic above the insulation. *Using an attic fan to cool your house has limited value.* A properly sealed and insulated attic will prevent the transfer of heat between the attic and the house, regardless of the temperature in the attic. Building components such as rafters and sheathing can easily withstand attic temperatures of 150 degrees or higher.

What about "destratification" of air layers?

Many claims have been made about the benefit of operating fans to move cooled or heated air from either the floor or ceiling—destratifying the different temperature layers. Although there might be some layering in larger buildings, the difference between floor and ceiling in most homes is usually only a degree or two. Regardless, the operation of heating and air conditioning blower fans will be adequate to keep the air well mixed in most residential situations.

Again, the primary effect of moving air from portable and ceiling fans is to cool our bodies. There is no benefit to operating fans in unoccupied rooms to "mix the air" for cooling, and there is a negative impact for operating fans in the winter—because they actually cool our bodies.

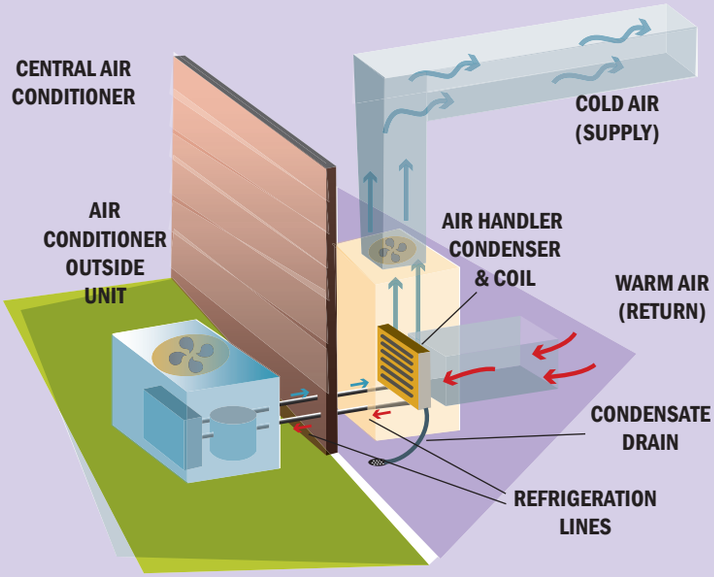
Air conditioning

Air conditioning operates on the same principles as a refrigerator: a refrigerant is compressed from a gas to a liquid and when it changes back to a gas, energy (in the form of heat) is absorbed. That captured heat is expelled to the outside, lowering the temperature inside the house. Additionally, as air is cooled it is less able to hold moisture, so the air inside the house becomes drier—which is more comfortable for the occupants.

All air conditioners consist of a condenser unit, which sits outside the house and serves to condense the circulating refrigerant, thus releasing the captured heat to the outside. The now-cold refrigerant is pumped to the evaporator, which is located inside. As the fan blows air over the evaporator it transfers its heat to the refrigerant. The air that is distributed is now much cooler, and the warmed refrigerant is pumped back outside to the condenser to start the cycle again.

Distributing the cool air

The actual equipment that accomplishes the "conditioning" of indoor air comes in several forms, depending on the type of distribution system in the home.



Where does the moisture go?

A significant effect of air conditioning is the removal of moisture—a result of cooling the air. But where does it go?

In a central air system, the moisture is collected in the evaporator within the furnace ductwork. This water, or "condensate," is carried away by a hose to a nearby drain. It is very important this hose remain open and connected to the drain. Condensate backup (due to clogs, pinches, or bends in the hose) will spill onto the floor, adding moisture back into the air and causing potential damage.

Window units also have a drain, which empties outside. Often a drain line will need to be attached to assure the condensate is draining away from the window frame and building.

Ducted or forced-air systems

The most common type of distribution system uses the same metal ducts and a fan that move heat created by a furnace—the forced-air system. The ducts can also serve as pathways for cool air; this system is commonly known as central air conditioning. Usually controlled by the same thermostat that operates the furnace, central air offers the convenience of cooling the entire house, while allowing for adjustments (through baffles and registers) in individual rooms.

Ductless systems

Ductless systems work well for homes that use hot water or steam for their heating systems, and thus do not have traditional ductwork. Small tubes run between the outdoor condenser and the indoor wall-mounted unit, forming a closed-loop system. The cooling component is mounted on the walls of one or more rooms and resembles a room air conditioner, but it is much quieter. The condenser is installed outdoors, similar to a central air conditioner. Some ductless systems will support multiple terminals and may have a cooling capacity equal to traditional central air systems. Another advantage of the ductless system is the ability to cool only selected rooms.

High velocity systems

Another option for homes without traditional ductwork is the high velocity system, which uses smaller ductwork that can be placed within existing wall cavities. Main trunks may be only six inches in diameter, with delivery ducts only three inches in diameter. Along with the outside condenser unit, the systems include an air handler with a higher velocity fan that blows air over the evaporator unit and then through the smaller ducts. Although sometimes challenging to install, a high velocity system can deliver cool air throughout the home and allows for individual room controls through registers.

Window/wall units

Most common in rental units and older homes, window/wall air conditioners can provide cooling to a limited area in a home—usually one or two rooms at most. A window air conditioner combines the condenser and evaporator elements into one unit that sits within an open window frame. A wall unit is similar except that it sits in a separate opening in the wall. The condenser portion is on the outside and expels the heat, while the room air is circulated over the evaporator on the inside, providing cooling into the room. Proper installation of window units will prevent air leakage around the unit (through insulated "filler" panels and other tight-fitting gaskets) and will provide a way to secure the window to prevent opening from the outside.

Additionally, it is important to make sure the electric requirements of the unit are not more than the circuit it is using.

Air conditioner repairs and maintenance

A central air system uses the same ductwork, fan, and controls as the forced-air furnace, so some of the maintenance requirements are the same. A qualified service technician should also:

Inside unit

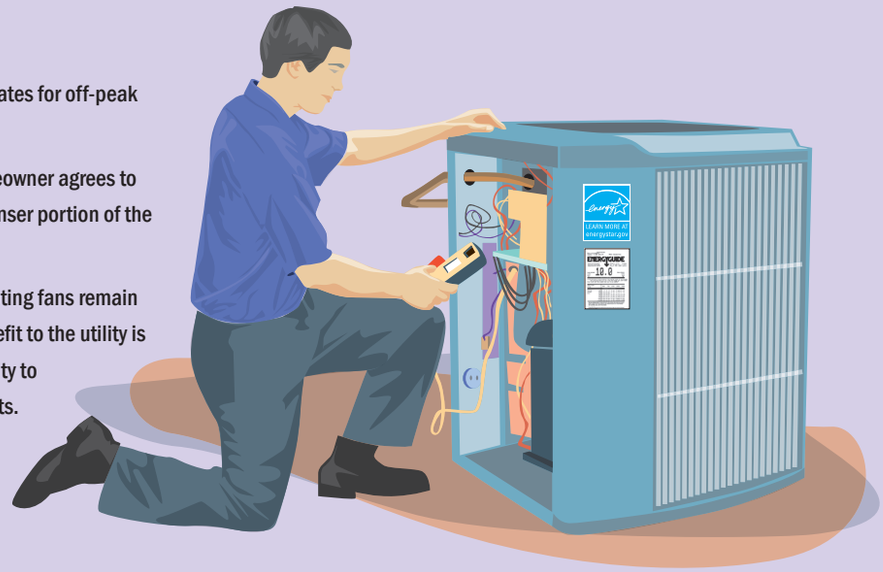
- Inspect and clean evaporator coil, drain pan, and condensate drain lines
- Inspect control box, wiring, and connections for wear or damage
- Ensure insulation on tubing is intact

Saving electricity with a central air conditioner

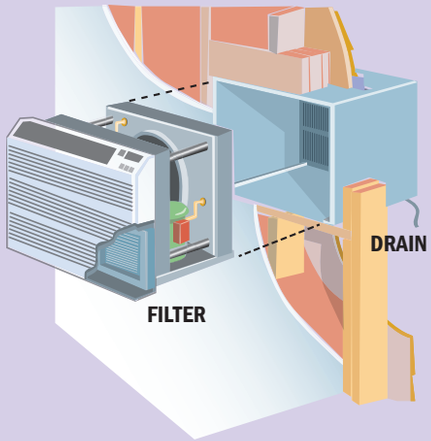
Some electric utilities offer billing options that include lower rates for off-peak use of air conditioners, often during evening hours.

Additionally, many will provide a discounted rate when a homeowner agrees to allow the utility to remotely control the operation of the condenser portion of the unit during periods of high electricity demand.

Usually the interruptions are not noticed by customers (circulating fans remain operational, and the "down" times are usually short). The benefit to the utility is better management of electric demand, which means the ability to avoid relying on expensive generation during peak usage events.



IN-WALL AIR CONDITIONER



Fuels for air conditioning

The primary fuel used to provide air conditioning is electricity. It is required to operate pumps, fans, and condensers. In many homes, air conditioning represents the largest portion of electric usage, on an annual basis.

A solar absorption chiller can provide the energy required to convert the refrigerant to a gas instead of using a compressor.

In a gas absorption chiller, like a gas refrigerator, the pump that is used to force the refrigerant through the compressor is run by natural gas instead of electricity.

Ground source and air source heat pumps can also provide cooling, and in some cases can be a very effective use of these technologies. With a ground source heat pump, the fluid coming from the loop field is already cool—about 55 degrees—so it is relatively simple to circulate through the distribution system. Air source heat pump units can also provide cooling, but careful design and proper installation will determine effectiveness and efficiency—especially when compared to other alternatives.

Outside unit

- Inspect for proper refrigerant level
- Clean dirt, leaves, and debris from inside cabinet
- Inspect base pan for restricted drain openings—remove obstructions as necessary
- Inspect coil and cabinet—clean as needed
- Inspect fan motor and fan blades for wear and damage—on older models lubricate as needed
- Inspect control box, wiring, and connections for wear or damage
- Inspect compressor and tubing for damage
- Ensure penetrations through the house are properly sealed

Additionally, there are a many things that homeowners can do to keep their air conditioners operating efficiently and safely:

- As with the furnace, air filters need to be changed per manufacturer's recommendations. Restricted airflow can cause the evaporator coil to freeze up, reducing efficiency and potentially damaging components.
- The area around the outside unit must be kept free of foliage or anything that can block airflow to the unit.
- The coils of the outside unit can get clogged from leaves, dust, or other debris, thus reducing efficiency. Periodically spraying with a hose can ensure proper operation.
- Window units require filters to be cleaned, drain lines to be clear and held away from siding, and proper sealing between the window and the unit.
- Ductless and high velocity systems also have filters that need cleaning or replacing.

Replacing an air conditioner

Central air conditioners have an expected life of about 15-20 years and can show signs of their age through refrigerant leaks, motor failures, and an inability to efficiently cool the house. Installing a new unit before the old one fails completely allows for time for careful shopping, as well as enjoying the energy savings of a high efficiency unit.

Proper sizing

Over-sizing an air conditioner is the most common mistake made by consumers, thinking that "bigger is better." 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.

The primary tasks of an air conditioner 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, and not a humidistat, the unit comes on and shuts off in response to air temperature, regardless of humidity. 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. A properly sized unit needs an operating cycle long enough to balance the removal of both heat and humidity.

Factors such as the amount of shade around your house, window area, and the insulation and tightness of the building envelope will also help determine the correct size of an air conditioner for your home.

Make sure that your contractor does a heat-gain calculation to ensure the proper sizing of the equipment.

Efficiency ratings

Because air conditioners operate on electricity, more efficient models will not only save money, they will also

reduce environmental effects related to electricity generation.

Since 2006, all residential central air conditioners sold in the United States must have a seasonal energy efficiency ratio (SEER) rating of at least 13. The higher the SEER rating number, the more efficient it is for cooling. ENERGY STAR® qualified units must have a SEER rating of at least 14, and there are units available with SEER ratings of 20 and higher.

Room air conditioners are also required to carry an "Energy Guide" label showing their energy efficiency ratio (EER). A higher EER rating means higher efficiency. Purchase an ENERGY STAR® model with an EER of 11 or higher.

Ultimately, purchasing the most efficient air conditioner will provide energy-savings payback over the life of the equipment.

Dehumidifiers

Considerable cooling effects can be achieved with the use of a dehumidifier in certain situations. Often found in basements (because of the cooler temperatures and higher humidity levels), dehumidifiers have a bucket or pan that can be periodically emptied. Most have an automatic shut-off when the container is full. Many units also allow for the attachment of a hose that can be run to a floor drain.

One downside of a dehumidifier is that it pumps out heat as a result of the dehumidification process. Generally this is minimal, and the dryer air offsets the additional heat gain.

Relative humidity and humidistats

Relative humidity (RH) is the amount of water vapor actually present in the air compared to the greatest amount of water vapor the air can hold at that temperature. The optimum RH level for a building is generally considered to be between 30% and 50%. Anything above this range may promote bacteria growth. (In Minnesota's climate, during the heating season, humidity levels should be in the range of 30% to 40% RH to prevent window condensation.)

Many dehumidifiers include a built-in humidistat, a device that allows you to set the desired RH level that you would like for the room. Once the room reaches the desired RH level, the dehumidifier will cycle on and off automatically to maintain the level.

Efficiency: energy factor

The energy efficiency of dehumidifiers is measured by the energy factor (EF). In general, a higher energy factor means a more efficient dehumidifier. ENERGY STAR® models have an EF of at least 1.85 for units that remove less than 75 pints/day and 2.8 for units that remove from 75-185 pints/day.

Why is humidity bad?

High humidity in a home will cause the occupants to feel much warmer, due to simple laws of physics. The higher the humidity in the air, the harder it is for sweat on our bodies to evaporate, which is how we cool ourselves in warm conditions. Even a cooler environment, with high humidity, will feel clammy and uncomfortable—think of a cool, damp basement.

Additionally, high humidity coupled with warm temperatures contributes to the growth of mold and mildew, especially on cooler surfaces such as tile or foundation walls.

Controlling humidity through proper sizing and use of air conditioning equipment, along with use of dehumidifiers, can reduce the impact of humidity on occupants and their homes.

Dehumidifier

Many people are interested in generating electricity on-site to power their home; some because they are off the electrical grid and others because they want to reduce their personal carbon footprint. Although there are several technologies that could be considered, for most residential settings solar photovoltaics (PV) are the most practical option.

Why consider solar PV?

Generating electricity from sunlight has been done for decades, and over the past few years the technology and market has matured to the point of widespread use. Improved efficiency, lower costs, and incentives have made residential rooftop solar a good choice for many Minnesotans.

Goals of home solar PV installations

Supplemental. Most solar PV installations are designed to provide a portion of the home's electrical use and are tied in to the electrical grid system. When the panels are producing electricity, the power is used to operate anything in the home that is drawing current. Excess electricity is sent into the utility's electric grid, and a meter measures the amount so that the homeowner can be reimbursed by the utility for the excess electricity generated. Because the system is tied into the grid, special permits, approvals, and equipment are required by the utility to ensure safe operation.

Offset. Installing a solar PV system to specifically offset electric use by selected equipment (such as electric vehicle charging or powering a heat pump) is one way to add electric load while staying carbon-neutral. These systems can be roof, ground, or pole-mounted and on- or off-grid. If designed to offset specific equipment, the system can be sized to meet just those electrical needs. Larger systems can send excess electricity to the grid or to battery storage.

Off-grid. Cabins or other remote locations that are not on the grid can use solar PV to provide all of a home's electricity needs. Because of the intermittency of sunlight (night and clouds), most off-grid systems include some form of storage, usually in the form of batteries. Additionally, electrical usage is usually reduced considerably through high efficiency products (LED lighting, for example) and choosing non-electric options for devices such as water heaters.

What to do before you install solar

Before investing in solar, first consider making some basic home improvements that will save energy:

- Get an energy audit
- Seal air leaks and add insulation
- Repair or replace old appliances
- Replace old lighting with high-efficiency LEDs
- Use a programmable or smart thermostat

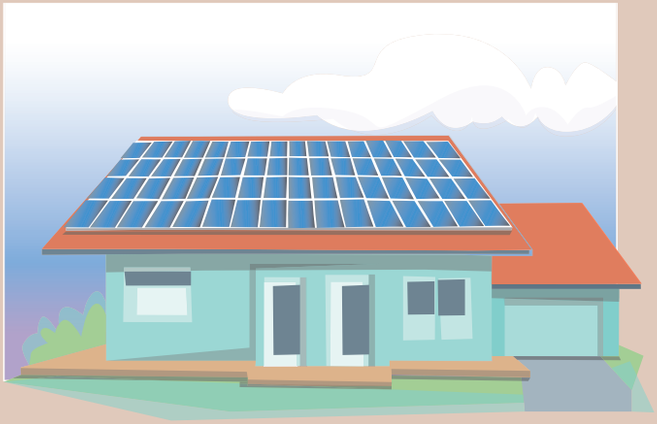
By making your home energy efficient first, you reduce your energy consumption—which will reduce the size of investment needed for your solar energy system, and maximize the returns on your system.

The importance of proper siting

Once you have decided on the type of solar PV installation you are interested in and have invested in conservation and efficiency measures for your home, you need to determine the suitability of your site. A good first step is to enter the property address into the Minnesota Solar Suitability Application (***mn.gov/solarapp).*** Clicking on various locations, including roof surfaces, can provide basic information about the solar potential. A more detailed analysis of the site—including future shading concerns from trees or potential issues with the structure planned for mounting—can be provided by a qualified solar professional.

DIY for solar PV?

The complexities of sizing, siting, purchasing, installing, permitting, and interconnecting a solar PV system are beyond the scope of what most homeowners are able to do. Additionally, most municipalities and utilities require licensed electricians to connect to the electrical grid.



What to expect from a reputable solar installer

- ***Qualifications:*** A licensed Minnesota contractor in good standing with the Minnesota Department of Labor and Industry (***dli.mn.gov***); proof of insurance; certification by the North American Board of Certified Energy Practitioners (***nabcep.org***); and customer and business references on request. To find installers, check out the Clean Energy Project Builder (***cleanenergyresourceteams.org***).
- ***Site Assessment:*** A detailed assessment of your site, including a shading analysis and examination of roofs and other structures to determine feasibility of a solar installation.
- ***System Sizing:*** Calculations that show the number of panels needed to meet a specific percentage of current usage and estimated annual production of the system.
- ***Permits and agreements:*** All necessary building permits, interconnection agreements, and documentation for incentives and manufacturer/installer warranties.
- ***Manufacturer and installation warranties:*** Most solar panels and collectors will have a warranty that guarantees a minimum of 80% output of the name plate capacity for 25 years. The warranty for workmanship by the installer is usually two to five years.
- ***Costs:*** A detailed bid contract that describes all the work to be done and who is doing it (including any subcontractors), all the equipment and materials to be installed, timeframes for completion, payment specifics, and process for any change orders. (See page 67 for further information about contracts.)
- ***Rebates and Incentives:*** Documentation for all applicable rebates and incentives and ensuring timely filing.
- ***Inspections:*** Arranging for all required inspections of the project.

Other Solar Options

Many people are unable to install a solar energy system on their home or business (because of siting issues, financial hurdles, or because they are renters) but still want to do what they can to support clean energy. Among the options:

- ***Green Pricing Programs.*** Green pricing is a voluntary option offered by some Minnesota electric utilities that allows you to support renewable energy beyond what your utility would otherwise be required to do. You usually pay a little more for your energy to cover the incremental cost of the additional wind or solar energy. Check with your utility to see if it offers green pricing.
- ***Community Solar Gardens.*** An emerging option for the customers of several Minnesota electric utilities is joining a community solar garden. These solar photovoltaic systems provide electricity to participating subscribers and are a way for people to get some portion of their power from solar electric systems without installing their own project. The Clean Energy Resource Teams offers information on community solar gardens (***cleanenergyresourceteams.org***).

Rebates and Incentives

There are several ways for Minnesotans to get financial assistance for installing solar PV at their home or business:

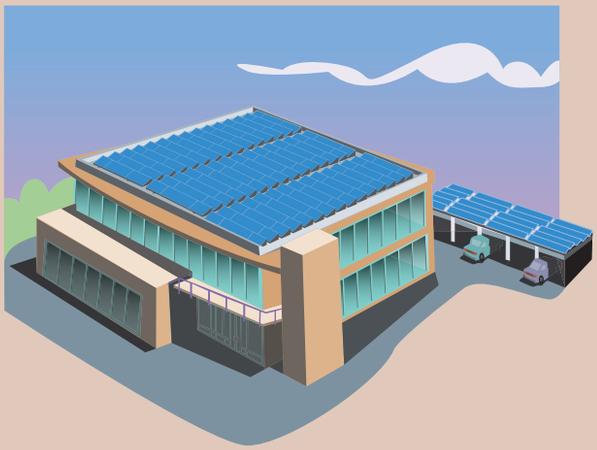
Federal Tax Credit. The US Congress recently extended the personal income tax credit for qualified solar installations through 2021.

Made in Minnesota (MiM) Solar Incentive Program. MiM is a solar PV incentive and solar thermal rebate program for homeowners and businesses who install solar modules and collectors certified as manufactured in Minnesota. Customers of Xcel Energy, Minnesota Power, and Otter Tail Power (for solar PV installations) and any MN resident (for solar thermal) who apply through 2023 are eligible for funding through an annual lottery. To learn more: mn.gov/commerce

Utility Rebates & Incentives. Some Minnesota utilities offer rebates or other incentives for customers installing qualified solar energy systems.

Loan Programs. Several organizations, including the Minnesota Housing Finance Agency, offer consumer loans for the installation of solar systems.

To learn more about available rebates, incentives, tax credits, and loan programs, visit the Database of State Incentives for Renewables and Efficiency (*dsireusa.org*)



Good indoor air quality is important for a healthy home. Proper and efficient ventilation removes unhealthy contaminants (such as smoke from cooking, moisture from bathing, or combustion products from heating systems) and brings fresh air into the living spaces.

Types of ventilation systems

There are two basic types of ventilation systems in homes: "point source" and "balanced."

Point source ventilation

Point source ventilation is located near the source of the contaminated air, such as in a kitchen, bathroom, or workshop. These are usually exhaust only systems—pulling air from inside the house with a fan and exhausting it to the outside through ducts—and are usually controlled by separate, manual switches.

The need for 'make-up' air

When exhaust fans operate they pull air from the house—air which needs to be replaced, somehow. In the past, this was done with air that leaked into the building around windows, doors, or foundation cracks. In a well-sealed home, however, there are very few of these leaks. Without an additional source, the fans pull air down chimneys, flues, or other exhaust fans, leading to the entry of dangerous combustion products or other contaminants. The solution is to provide sufficient air to "make-up" the air that is being exhausted. This is usually done with an insulated duct that enters the house (often in the basement). When properly installed, this duct will only allow the entry of air when needed.

Bathroom fans

Building code requires that bathrooms have either an operable window or a fan to remove odor and excess moisture. A bathroom fan is often quicker and more effective than opening a window—especially during heating or cooling seasons.

In order to minimize moisture buildup and mold, it is essential that bathroom fans be installed properly, using short, insulated ducts with no bends or kinks. Additionally, fans must be air sealed at the ceiling and insulated to prevent heat loss into the attic, and ducts must be sealed at all joints and connections, all the way through to the exit point at the roof or wall.

ENERGY STAR® rated fans are not only much more efficient, they also are quieter and have a longer estimated life.

Kitchen fans

Most kitchens have hood fans over the stove top or range. Unfortunately, many are not connected to ducts that lead to the exterior, and are merely "recirculating" the air through the fan filter. Although this may collect some of the larger particles of grease, these installations will do little to control smoke, odor, or the by-products of combustion (from a gas stove or range).

The same requirements for proper installation apply to kitchen fans as to bathroom fans, and ENERGY STAR® products will perform better than standard ones.

High volume fans require extra precautions

Found in some kitchens, workshops or utility areas, exhaust fans of over 250 cfm (cubic feet per minute) can do a very

Point source ventilation

Kitchens and bathrooms are the primary locations where point source ventilation is required, to remove odor and excess moisture from the air.

good job of removing smoke, dust, and other contaminants very quickly. However, their very power can lead to problems with inadequate air supply and they usually require additional make-up air.

Exhaust fan use

Exhaust fans should be used whenever there are indoor air pollutants (including moisture from cooking or showers) that are present in the home. Exhaust fans should be run whenever the pollutants are being introduced into the air and for at least 15 minutes after the pollutants have stopped occurring in the home or until signs that the pollutants have left the home (for example, when there is no longer any condensation on the windows after a shower). The use of a timer switch to control exhaust fans is a good way to provide adequate ventilation and limit run time.

Balanced ventilation: air exchangers

Air exchangers do exactly what their name implies: they exchange stale indoor air with fresh air from the outside. Although the energy savings derived from using an air exchanger is often minimal, the benefits to occupants are significant. As buildings have become tighter, less air moves through leaks around windows, doors, chimneys, etc. This can lead to an unhealthy build-up of odors, carbon dioxide, or volatile organic compounds (VOC). Opening a window may allow fresh air in, but at a considerable energy loss. Air exchangers provide the fresh air needed for occupants and minimize the energy losses for heating or cooling.

- Heat recovery ventilation (HRV) is a system that exhausts air from inside of a home and replaces it with outdoor air. During this process the system captures heat from the air being exhausted and uses it to preheat the air entering the home. The air flows (fresh and exhaust) don't mix.
- Energy recovery ventilation (ERV) is a system that does everything that an HRV does with the addition of transferring moisture from the exhausted air into the air entering the home (in the winter) and restricting moisture from incoming air (in the summer). This can provide higher comfort for occupants by balancing the humidity levels inside the home.

Maintenance of ventilation systems

All ventilation systems require periodic maintenance to ensure safe and efficient operation.

- HRV and ERV units should have filters cleaned or replaced in the spring and the fall. Vent openings on the exterior of the home should also be checked for blockages from snow, debris, or insects.
- Exhaust fans should have the fan cleaned once a year, and the dampers on the venting should be inspected once a year to ensure that they are working properly. Kitchen exhaust fans should have the metal filters in the hood washed every few months or when grease builds up.

Attic or home ventilation: What is the difference?

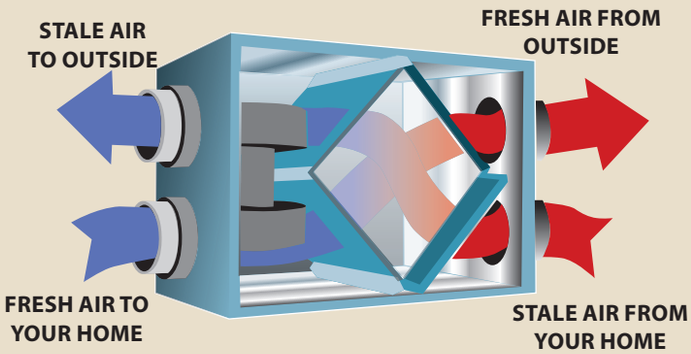
Many people confuse the ventilation requirements of an attic with those of the living spaces below. The two types of ventilation are not related and the systems are completely separate.

Attic ventilation is needed to protect the insulation and building materials in the attic from excess moisture, caused primarily by air leakage from the moisture-laden living space. Although sealing air leaks will reduce the need for attic ventilation (and reduce energy use and ice dam risks), minimum attic ventilation is still required.

The ventilation required for the living space, however, is all about providing a safe and healthy environment for the occupants by replacing contaminated air with fresh air.

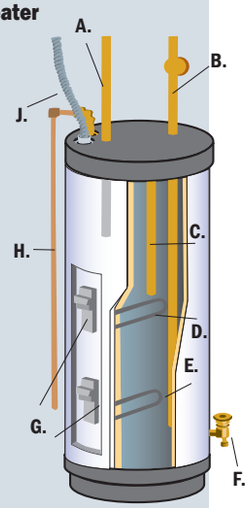
Balanced ventilation

Air exchangers provide fresh air for occupants that used to be provided by leaky houses—before we insulated and sealed them properly.



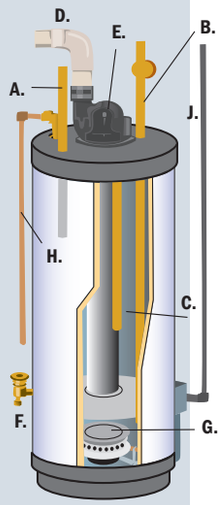
Electric Water Heater

A. hot water outlet
B. cold water inlet
C. anode rod
D.upper element
E. lower element
F. drain valve
G. thermostats
H. overflow pipe
J. electrical supply



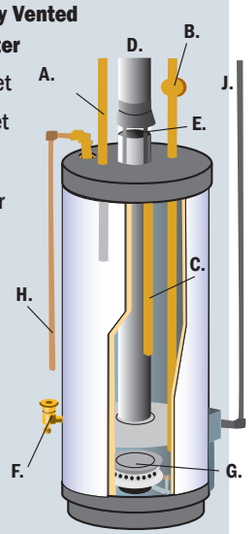
Power Vented Gas Water Heater

A. hot water outlet
B. cold water inlet
C. anode rod
D. pvc exhaust vent
E. blower motor
F. drain valve
G. burner
H. overflow pipe
J. gas supply



Atmospherically Vented Gas Water Heater

A. hot water outlet
B. cold water inlet
C. anode rod
D. vent connector
E. air gap
F. drain valve
G. burner
H. overflow pipe
J. gas supply



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

Water heater options

Water heaters heat water by using electricity or by burning a fuel (natural gas and propane are the most common). In most cases heated water is stored in a tank and is ready for use when needed. Some only heat water whenever it is called for by the user; these are known as on-demand or tankless water heaters.

Gas-fired water heaters

Gas water heaters are the most common type in use in Minnesota. Typical gas models have a burner under the tank and an exhaust stack/heat exchanger that runs through the middle of the tank. The exhaust stack has two functions: it is a vent for the burner and it transfers heat to the water.

- Atmospherically vented water heaters use room air for combustion and direct the exhaust gasses through a double-wall (class B) chimney through the roof of the house. These units are commonly found in older homes and are the least efficient option. They also carry a risk of backdrafting in certain conditions.
- Power-vented water heaters are similar to atmospheric models in that they rely on room air for combustion, but they feature an exhaust system that is assisted by a fan. This reduces the risks of backdrafting. Because of their higher efficiency most models can be vented through a sidewall or vertical roof vent using PVC piping.
- Sealed combustion or condensing water heaters use only outside air for combustion. Again, because they are more efficient at extracting heat from the combustion process, most of these water heaters can be vented with PVC piping.

Electric water heaters

Most electric models use resistance coils inside the tank. Electric water heaters typically have slower recovery rates than many gas models. They make up for that with larger tanks. Electric water heaters may be more expensive to operate than gas models (depending on rates), but they do have some advantages. Electric units have no chimney or flue pipe, so you can put one almost anywhere in your home—for instance, in a closet or under a sink. The entire tank is surrounded with insulation, so less heat is lost when compared to a standard gas model.

Some local electric utilities offer incentives for installing storage heaters for off-peak applications or control devices that shut off the water heaters for interruptible service:

- ***Off-peak electric options.*** Storage heating is an inexpensive and efficient method of electric water heating. Many utilities offer low-cost off-peak night electrical rates for water heating. Water is heated at night, storing all you need for daily use. Make sure you have adequate storage capacity and check with your utility company for details.
- ***Interruptible electric*** water heating allows the utility to temporarily interrupt electricity to the water heater during times of peak electrical usage, usually for a few hours only on the hottest or coldest days of the year.

Mobile home water heaters

It is very important to install the correct type of gas water heater in a mobile home (or manufactured housing). If your mobile home has an exterior access door, you may use a standard mobile home water heater with an open draft hood (atmospheric vent). If your water heater access door opens to the interior or your water heater is located in a cabinet or closet, you must install a direct-vent mobile home water heater. A direct-vent water heater is designed to prevent the accidental spillage of flue gasses into the home. The

letters "DV" will appear in the model number.

Space heat and water heater combination units

Almost all high efficiency boilers can be made to heat potable water. This may be done with an indirect fired water heater, also known as a sidearm water heater. This type of water heater provides 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, being 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.

Tankless or on-demand

Tankless or on-demand water heaters have no storage tank; they heat water only as it is needed. These units can be the whole house type (installed in a basement or mechanical room) or can be individual units located near demand points, such as under kitchen sinks. Fueled by either gas or electricity, on-demand water heaters require a large amount of energy over a very short period of time. Because of this, it is important to ensure that electric circuits or gas lines are sufficient to handle the increased demand.

Heat pump water heaters

Heat pump water heaters (HPWH) take heat from the surrounding air inside the house, or air that is ducted to the unit, and transfer it to the water in the tank.

Benefits include dehumidification, a reduced cooling load in the summer, and significant energy savings (when compared with a standard electric resistance water heater). In fact, new federal standards require new electric storage water heaters greater than 55 gal. to use heat pump technology.

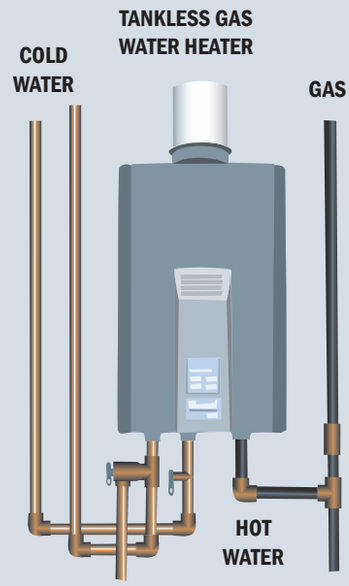
There are two types of HPWHs: integral and remote. The integral unit is a heat pump with its own water tank. The remote unit is a heat pump that can be connected to an existing electric resistance water heater tank. The remote unit is less expensive than an integral system. Both types have a resistance element as a backup, either built into the integral unit or left over in the old system to which the remote unit was added.

Ground source heat pumps (GSHP) can also provide water heating in homes with an adequately sized ground source heat pump heating system. There are two water heating options available, and both are generally installed to preheat water in an extra tempering tank.

- ***Desuperheater water heaters*** attach to the heat pump and make use of the compressor's waste heat. A desuperheater water heater can satisfy 60% of domestic hot water requirements during the cooling season and 40% during the heating season. While it provides very economical heat during the air conditioning and heating seasons, it does not contribute to heating water during spring and fall periods when the compressor is not operating.
- ***Water source HPWHs*** are another way to take advantage of a GSHP heating system. A small water source heat pump is tied into the ground source loop to preheat water. The water will be preheated year-round, without the need for the space heating compressor to be operating. Note that with this system the ground loop will need to be sized larger to serve both the space heating and water heating needs.

Solar water heating

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 water heater system preheats the water before it reaches the conventional water heater. During the summer, the system may provide all of the required heat.



Tank or tankless?

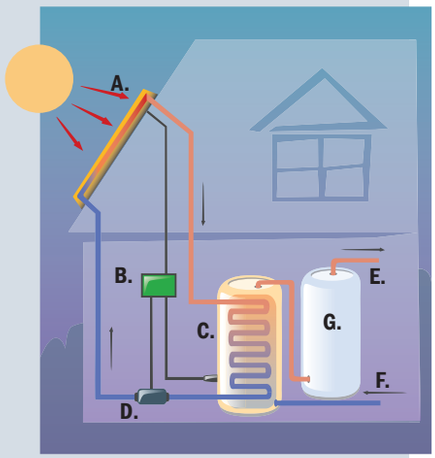
When replacing a water heater, many people have questions about the differences between tank and tankless systems. In terms of energy efficiency, there is no difference between units that have the same energy factor (EF): it takes the same amount of BTUs to heat water to a given temperature.

Where the real difference is lies in what is known as "stand-by" loss, or the amount of heat that escapes through the walls of a tank system when there is no demand for hot water. In an older or less insulated tank, this loss can be significant; newer high efficiency models are very well insulated, and standby losses are greatly reduced.

Another concern is estimated water usage for a household. Larger families with higher demand may find that some tankless units are unable to deliver sufficient hot water for simultaneous uses. Select models based on your hot water needs.

Finally, when comparing purchase and installation costs, consider upgrades to gas or electric service that may be needed for the high momentary demands of a tankless system.

Solar water heater
A. solar collecter
B. controller
C. exchanger tank
D. pump
E. to taps
F. cold water supply
G. water heater / storage tank



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
- a controller

There are many types of solar water heater systems, but only two are appropriate for the Minnesota climate—the closed-loop heat exchanger and drainback systems. Both of these types have protection against winter freezing.

Biofuels

Wood and other wood products (chips, pellets, etc.) can be used to heat water. One approach is to use a tempering tank in the same room as the wood furnace or stove, which then preheats the water in the tank before entering a standard water heater. Another option is a wood-fueled boiler that can provide domestic hot water needs along with space heating.

Water heater repairs and maintenance

Water heaters require maintenance in order to operate efficiently and safely. Often a part of annual furnace inspections, a technician should check the following to keep a water heater running properly.

- Check the temperature at a nearby faucet. A maximum of 120 degrees is recommended.
- Check for leaks around the pressure valve and discharge pipe.
- Ensure nothing is stored on or near the water heater—especially anything combustible!
- Electric: inspect the anode rod every three to four years.
- Gas, atmospheric: test the draft of the water heater with all exhaust fans (including the dryer) and the air handler running.
- Gas: check the fuel input and flame characteristics and adjust the fuel pressure if necessary to achieve the optimal efficiency and an acceptable CO reading in the flue.
- Gas: ensure that the fresh air supply (atmospheric and power vent) is open and that there are no obstructions at the air intake for the burner.
- Inspect all gas, electrical, and venting lines to ensure there are no leaks, breaks, or loose connections.

When to replace

Water heaters have an average life expectancy of 10-12 years, but they can last much longer. Most, however, are not replaced until the tank fails and begins leaking—potentially damaging furnishings or structure. Additionally, an old water heater can operate for years at very poor efficiencies before it finally fails. It is often cheaper (and more convenient) to remove an operating but inefficient older unit and replace it with a new high efficiency model.

Ask yourself the following questions:

- Does the water heater make popping or cracking noises? This indicates a buildup of sediment in the tank.
- Have you been forced to turn up the temperature setting 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?
- Is there evidence of soot or burn marks near the vent hood at the top of the tank? This may indicate dangerous backdrafting.

If you answer yes to any of these questions, it may be time to replace your water heater.

Proper sizing

Buy the right size 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 heating water that is never used.

The first-hour rating (FHR) is more important than the actual size of the tank because it is an estimate of how much hot water the unit will deliver in an hour. The FHR is displayed on the Energy Guide label. Look for a new water heater with an FHR that is close to the estimate of your household's peak hour demand. If you only reach your peak once a week and use less hot water the rest of the time, consider adjusting your use to spread out demand and buy a smaller heater. To estimate your peak hour demand, check out an online calculator, such as what can be found at energy.gov.

Efficiency in a new water heater

When looking at a new water heater, compare the energy efficiency of different models by checking the Energy Guide label.

Energy-saving tips for water use

- Pipe insulation. Water pipes extending vertically from the hot water storage tank are actually 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. To prevent a fire hazard, the insulation should be kept at least six inches from the draft hood and flue of an atmospherically vented unit; it should not be installed if that clearance cannot be achieved.
- Using less hot water. Avoiding waste in using hot water is an effective and low cost way to reduce energy costs.
- Turn down water temperature. You don't need the water to be any hotter than 120 degrees. Temperatures over 120 degrees can increase the risk of scalding. Many new dishwashers feature a temperature boost setting which allows for a lower water heater temperature.
- Fix leaky faucets. A hot water faucet leaking one drop per second will waste about 60 gallons of hot water a week. This could cost you up to $35 or more a year. Leaks can often be fixed by replacing the tap washer.
- Install flow restrictors on fixtures. Flow restrictors will save money on both the water bill and water heating costs. They reduce the amount of water used for tasks that require flowing water without greatly changing the feel of the flow.
- Install a water-saving showerhead. A typical showerhead uses between 4-9 gallons of water a minute. A water-saving showerhead uses between 2-3 gallons per minute, which means it can save you 1-7 gallons per minute; and most of the water is hot. If your water heater is set at 120 degrees, you can easily pay for the new showerhead in about a year of energy savings.
- Wash only full loads of laundry or adjust the water level for smaller loads. Use cold water whenever possible.
- Wash only full loads with the dishwasher.
- Use cold water to flush away food in your garbage disposal.
- Place your water heater 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.

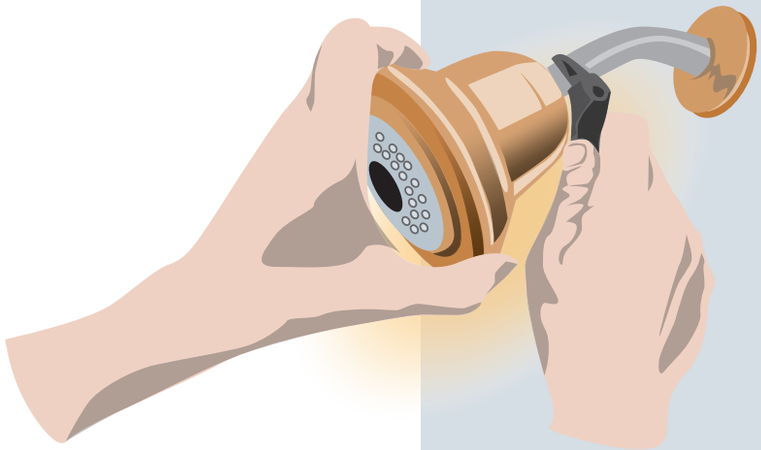
What is an *orphaned* water heater?

In the past, atmospherically vented water heaters and furnaces usually shared the same masonry chimney. When both were operating, the warm exhaust was sufficient to create a draft, pulling the exhaust gasses all the way out of the chimney. When coupled with the leakiness of unimproved homes, the dangers of backdrafting were greatly reduced.

However, when a new high efficiency furnace is installed, the masonry chimney is no longer used to remove the furnace exhaust; that is now vented through a plastic pipe through the wall. This leaves the old water heater orphaned, and unable to generate sufficient draft under some conditions. Together with the tightness of many homes today, that increases the potential for dangerous backdrafting of the water heater.

The solutions are:

- install a CO detector (per code) to provide warning of any issues
- when it is time to replace the water heater, install a high efficiency unit (either power vent or sealed combustion)



A thermostat controls the temperature of the home (or a section of the home) by turning on the furnace or boiler when the temperature falls below a pre-set level or by turning on a central air conditioner when the temperature rises above a pre-set level. Thermostats can also control other mechanical systems, such as humidifiers and air exchangers.

Types of thermostats

There are three types of thermostats: manual, programmable, and smart models.

Manual thermostats

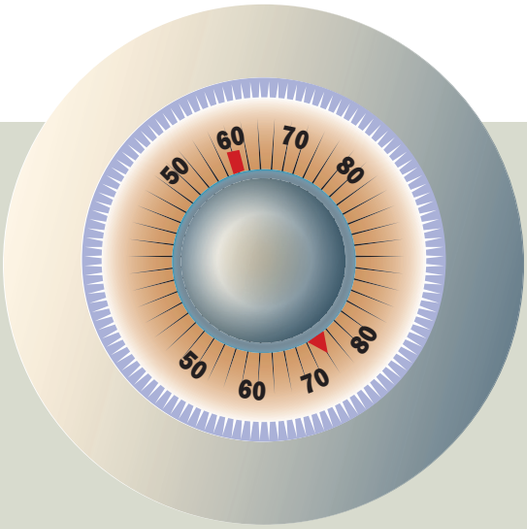
The traditional dial type of thermostat has worked for many years to control the heating and cooling of homes. It holds the set temperature and the home stays at that temperature until someone changes it. Often the settings are left at levels that are comfortable for people—even at night or when nobody is home—thus wasting energy. Manual thermostats may work best with electric resistance heat, radiant in-floor heat, heat pumps, and steam heat.

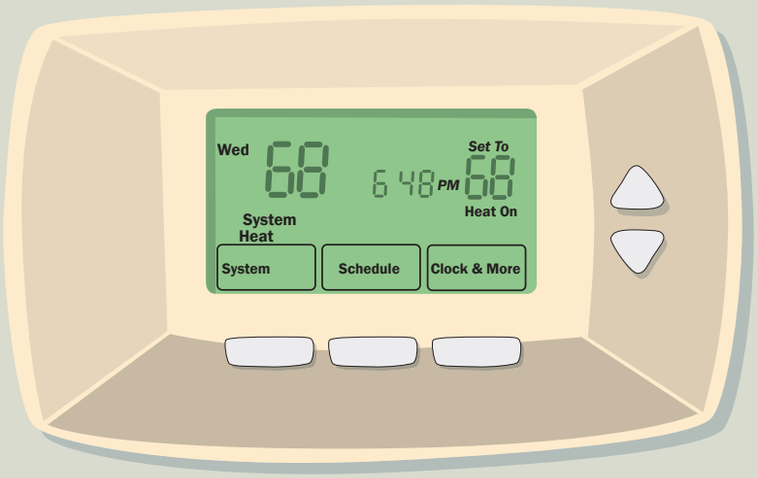
Programmable thermostats

Programmable thermostats allow users to change the temperature of the home based on the time of day and whether they are home or asleep. A digital programmable thermostat allows the settings to be changed or set at the thermostat itself, usually through a touch screen interface. Depending on the model, there may be up to four different modes available for each day: morning, day, evening, and night. The desired times for these modes can be selected, along with the desired temperature. Additionally, some models allow you to have different settings for weekdays and weekends. All programmable thermostats allow for overriding the programmed setting, to provide extra heating or cooling, for example, and most have a special setting for vacations. Additionally, most models can also control air exchangers, humidifiers, heat pumps, and other devices.

Smart thermostats

Smart thermostats operate essentially the same as programmable models, with one significant difference: they "learn" the preferences of occupants and adjust temperatures according to whether or not anyone is actually at home. Additionally, they are Wi-Fi enabled, allowing users to control settings through a smart phone app or computer. Monthly e-mail reports on usage and suggestions for energy savings are also included in most models. Finally, some are also linked with home security systems, providing remote monitoring and operation of many home functions.





Installation

Most programmable and smart thermostats are not complicated to install. Manuals and online videos can assist homeowners through the process, and usually the only tools required are screwdrivers.

Sometimes, however, programmable or smart thermostats may require wiring that is different from manual thermostat wiring. Especially if you plan to control additional devices, the wires may not be in place to do so. If you need additional wiring for a new thermostat, contact an HVAC contractor or an electrician to run the wires.

Proper thermostat location

The location of your thermostat can affect its performance and efficiency. To operate properly, a thermostat must be on an interior wall away from direct sunlight, drafts, doorways, skylights, and windows. It should be located where natural room air currents—warm air rising, cool air sinking—occur. Furniture will block natural air movement, so do not place pieces in front of or below your thermostat. Also make sure your thermostat is conveniently located for programming.

Programming your thermostat

When programming your thermostat or providing initial settings for your smart thermostat, consider the schedules of everyone in the household, including work/school schedules and sleep times. Consistent times when no one is home or when people are sleeping are good opportunities to lower the settings in the winter and raise it in the summer.

In order to save the most energy, start with settings that are lower in winter and higher in summer than what you are used to (66°-68° in winter and 74°-76° in summer). After a few days, evaluate your comfort, and adjust either the temperatures or the times when the temperatures change. Eventually, you should be able to balance comfort with maximum energy savings.

Why upgrade your thermostat?

Many people are reluctant to invest in newer thermostats, primarily because of concerns about initial purchase costs. The cost of a programmable thermostat is between $20-$150, depending on features; a smart model may be more.

But—if used properly—these models can actually save enough energy to offset their cost, sometimes in a year or so. But the key to their success is proper installation and use. A programmable thermostat that is not programmed (which some research shows may be up to 70% of households) will save no more energy than a manual thermostat.

In those situations, a smart thermostat may actually save more energy, as it requires less attention to operate efficiently.

Appliances are the most common labor-saving devices in our homes. Whether helping us keep clean, comfortable, or nourished, appliances are an essential part of daily life. And although they can save us a lot of time and effort, their use comes with an energy cost.

Refrigerators and freezers

Refrigerators use a lot of energy in a typical home. In fact, in most Minnesota homes a refrigerator is the second largest user of electricity, after air conditioners.

Maintenance & repairs

If you are not ready to replace your refrigerator or freezer, there are a few things you can do to keep your existing equipment operating as efficiently as possible.

- ***Cleaning and clearance.*** Although the benefits of keeping the coils on the back or bottom dust-free may be minimal, large accumulations or blockages can interfere with efficient operation. Additionally, there must be clearance between the appliance, walls, and cabinets so that air can circulate freely, allowing the coils to give off heat. Spilled food or liquids may also harden and keep doors and drawers from closing or sealing tightly.
- ***Gaskets and seals.*** Over time, the gaskets that seal the doors can become worn or loose and may no longer do a good job of keeping the cold inside. If the unit itself is still operating well and is not too old, these can be replaced or tightened.

When is it time to replace?

Many refrigerators and freezers will continue to operate for 15-20 years or even longer: food stays cold and the light comes on when the door opens. Whether or not these appliances are really working *efficiently*, however, is another question. Opportunities for replacement include:

- ***Costly repairs.*** If an estimate for repairs exceeds several hundred dollars, it might make sense to look at replacement instead—depending on the age and condition of the rest of the appliance.
- ***Remodeling project.*** A kitchen remodel often includes an upgrade of appliances, in order to accommodate a different space or additional features.
- ***High energy usage.*** Depending on the model, a 20-year-old refrigerator could use 1,700 kWh of electricity every year—compared with about 450 kWh for a similarly sized new ENERGY STAR® model. At an electrical cost of 11¢ per kWh, that represents a potential savings of $140 per year—and a potential payback of 7-9 years.

What has changed?

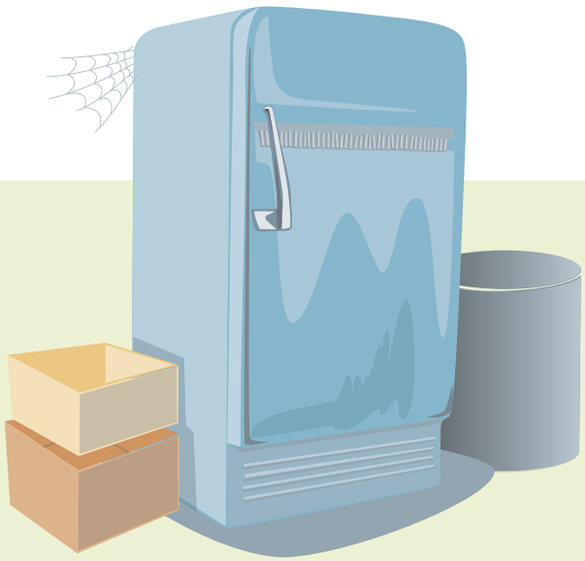
Refrigerators and freezers have benefited from recent advances in manufacturing methods and efficient technology, including:

- ***Better insulation.*** The metal boxes that enclose refrigerators and freezers have higher quality insulating materials than in the past, and reduced thermal bridges (the direct, uninsulated connections between inside and outside).
- ***Tighter seals.*** The gaskets and seals around doors are designed to fit better and have increased durability. Additionally, they are generally easier to replace when worn.
- ***More efficient.*** The compressors, motors, heat exchangers, and other components are considerably more efficient than previously.

Shopping tips

When choosing a new refrigerator or freezer, consider:

- ***Proper sizing.*** Appliances that are too large waste energy and space. Ones that are too small require more frequent



What *not* to do with your old refrigerator

Many people spend a good deal of time considering the energy efficiency of a new refrigerator and when their new model arrives, take the old, energy-wasting one and move it to the garage or basement—where it continues to waste energy!

Others, in an attempt to recoup some of the expense of a new unit, sell the old one. Instead of saving energy with their purchase, these folks have actually added to the overall electrical use.

Refrigerators that are 15 years old or older should be taken out of service and recycled. The cost of operating these older models (in both dollars and environmental effects) exceeds the perceived benefits of continued operation.

trips to the grocery store. A typical family of four requires a refrigerator capacity of 12-16 cubic feet and another 6-8 cubic feet for freezer capacity.

- ***Styles.*** The most efficient refrigerator designs usually have the freezer compartment on the bottom. The least efficient are usually the side-by-side models. Chest freezers are generally more efficient than vertical models (less cold air spills out of a chest freezer). Other factors such as compartment dimensions or easy access may be important as well.
- ***Features.*** Manual defrost typically uses less energy than auto-defrost models, but they may be difficult to find in all sizes—and they must be defrosted manually to properly operate. Although "through-the-door" water and ice dispensers can reduce frequent door opening, they can also add to the energy consumption.
- ***Efficiency.*** As major users of electricity, the selection of refrigerators and freezers will affect your utility bills—for 10-15 years. Buying efficiency today means lower operating costs for the future. The best way to compare efficiency of different models is through the ENERGY STAR® website, which contains tools to help you calculate savings on specific models and compare them with models with similar features.

Efficient use

Follow these suggestions to keep energy usage to the minimum:

- ***Limit the time that doors are open.*** Open doors allow cold air to escape and warm air to enter.
- ***Keep refrigerators and freezers relatively full.*** This will reduce the temperature swings that result from opening the doors. Jugs of water can also be used.
- ***Set temperatures.*** Refrigerators should be set to 38 to 40 degrees F and freezers to 0 to 5 degrees—any colder is not necessary for food safety and uses more electricity than needed. In fact, a refrigerator set 10 degrees colder (and a freezer set 5 degrees colder) may use up to 25% more electricity. Test with a thermometer and adjust accordingly.
- ***Unplug*** unused refrigerators and freezers or those in an unheated space—they may not work properly at temperatures below 55 to 60 degrees.

Dishwashers

At one time dishwashers were relatively rare in households; today they are a common component of many kitchens. Aside from obvious convenience and time-saving, dishwashers can also help to sanitize dishes, potentially reducing the occurrence of illness. In addition, an efficient dishwasher will actually use *less* hot water than washing dishes by hand.

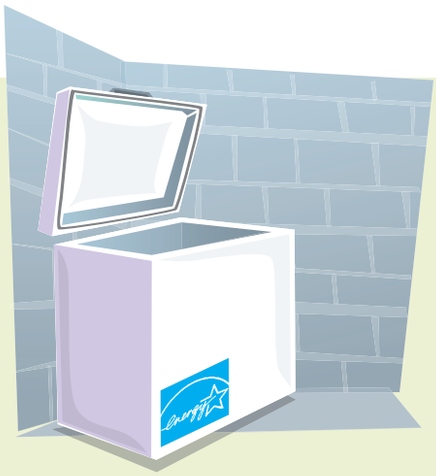
Maintenance and repairs

Depending on the model and features, dishwashers require very little maintenance to keep them running well. Screens on the bottom that trap large particles may need to be emptied and the spray arms need to spin freely. Door gaskets should fit tightly to avoid leakage; some older models may eventually need gasket replacement. Pumps and internal water heaters may also eventually fail and need repair or replacement.

When is it time to replace?

The expected lifetime of a dishwasher is about 10-12 years, and as it ages, the likelihood of repairs and replacement increases. As with refrigerators and freezers, the opportunities for replacement include:

- ***Costly repairs.*** If an estimate for repairs exceeds several hundred dollars, it might make sense to look at replacement instead—depending on the age and condition of the rest of the appliance.
- ***Remodeling project.*** A kitchen remodel often includes an upgrade of appliances, in order to accommodate a different space or additional features.

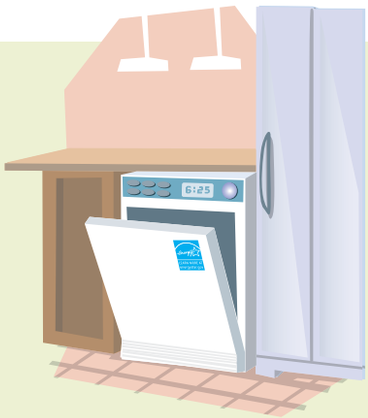


Freezers

Chest freezers are generally more energy-efficient than vertical freezers. Wire racks and bins can make organization and access easier in a chest freezer.

Dishwashers

Older dishwashers use more water and electricity than newer, ENERGY STAR models. With a typical lifetime of 10-12 years, efficiency can pay off when shopping for a replacement.



MEF, IWF, & HE washers

Clothes washers must meet minimum efficiency standards in order to be ENERGY STAR® labeled, including:

Modified Energy Factor (MEF) is a measurement of the energy efficiency of the washer, taking into account the electric energy, the energy to heat the water, and the size of the tub. ENERGY STAR® washers must have an MEF of 2.0 or greater.

Integrated Water Factor (IWF) is the measurement of how much water is used, related to the capacity of the machine. ENERGY STAR® washers must have an IWF of 4.3 or less.

The latest design in energy-saving laundry appliances is known as the **High Efficiency (HE)** washer. Nearly all HE washers are front-loaders (although some top loaders are now available) and they have several advantages over less-efficient versions.

HE washers:

- **Use less water.** Because they tumble clothes rather than agitate them, HE washers can use up to 75% less water than a standard washer.
- **Use less hot water.** Using less water means using less hot water, which saves the energy to heat the water (nearly 90% of the energy use in a typical washer).
- **Wring out more water.** A spin rate of up to 2,000 rpm removes much more water, and a moisture sensor limits the spin time. Less water at the end of the wash means less energy needed to dry the clothes.
- **Are gentler on clothes.** The tumble action is easier on clothes than a typical agitator.
- **Require a special HE detergent.** Because of how an HE washer operates, regular detergent will over-suds and not work properly. Buy only HE detergent and follow instructions carefully. (Hint: you use much less than with regular detergent.)

- ***High energy usage.*** A dishwasher that was made before 1994 will probably use up to 10 gallons of water per cycle and cost you $40 more in energy costs annually than a newer ENERGY STAR® model.

Shopping tips

When evaluating a new dishwasher, look closely at these features:

- ***Water heating.*** A dishwasher with a built-in heater and adjustable temperature settings gives you a variety of options: a lower temperature for china, a moderate one for day-to-day use, and a higher temperature for heavy cleaning. And heating the water in the appliance allows a lower setting of 120 degrees on your main water heater, saving energy and avoiding scalds.
- ***Sensors.*** Knowing how soiled the water is (and thus how dirty the dishes are) permits the dishwasher to adjust wash times and water temperature automatically, saving time and energy.
- ***Food grinder.*** This option eliminates the need for emptying screens before each use and helps sensors know when cleaning is complete.
- ***Delayed start time.*** Setting the dishwasher to operate late at night can reduce electric grid system loads and can keep you from running out of hot water for showers or laundry.
- ***Efficiency.*** The best way to compare efficiency of different models is through the ENERGY STAR® website, which contains tools to help you calculate savings on specific models and compare them with models with similar features.

Efficient use

Follow these suggestions to keep your energy usage to the minimum:

- ***Wash only full loads.*** Even with a sensor, you will still use nearly the same amount of hot water and electricity, regardless of how many dishes are inside.
- ***Do not pre-rinse dishes.*** It wastes hot water and is unnecessary with newer dishwashers. A simple scrape to remove the biggest pieces is usually sufficient.
- ***Use the least amount of detergent that will still clean your dishes.*** Excess detergent use can lead to spotting or etching, as well as environmental concerns.

Laundry equipment

The typical household in America cleans and dries about 300 loads of laundry in a year. Up to 90% of the energy used to wash clothes is used to heat water, and the energy use of dryers is directly related to the moisture content of the clothes; these two factors illustrate the energy-saving opportunities in a typical laundry room.

Maintenance and repairs

Older washers and dryers may require periodic maintenance to keep them operating properly. Here are a few things to check for:

Washer:

- Clean the tub of your washer every few months (or more often if indicated by odor or stains). Special cleaning products can be used in place of detergent and run through a complete cycle. Check with the manufacturer for recommendations.
- Inspect water and drain connections periodically for leaks. A buildup of rust or minerals at connections or stains along the side

of the washer or on the floor indicate a leak.

- Replace water supply hoses that connect to washers every 3-4 years. The hoses can become brittle and susceptible to failure, leading to a flooded basement or laundry room.
- Pumps and motors have a limited lifetime; repairs or replacements may eventually be needed.

Dryer:

- Clean the dryer lint screen before each load. Lint restricts airflow and increases drying time and energy use.
- ONLY vent dryers to the outside! Venting into the living space or attic will lead to high levels of moisture. In a basement it can lead to significant mold and mildew issues; in an attic it will lead to wet insulation, rot, and ice dams. Venting a gas dryer into the living space is also dangerous to the occupants because of flue gasses from the combustion process.
- Only use smooth, rigid, metal ducts for the dryer exhaust; connect sections with metal foil tape to prevent dangerous leakage of flue gasses into the living space. Flexible ducts restrict airflow and trap lint and are not permitted under the state firecode. Inspect periodically for leaks or separations.
- Inspect the outside exhaust vent monthly to insure the flapper is operating freely and no lint is blocking the opening. If the flapper sticks, lubricate the hinge or replace the vent. Poorly sealed exhaust vents can also be a source of air leakage and energy loss.
- Belts that drive the drum can stretch or break, necessitating adjustment or replacement.

When is it time to replace?

The expected lifetime of a washer and dryer is about 12-14 years, depending on model, use, and maintenance. Replacement opportunities include:

- ***Costly repairs.*** If an estimate for repairs exceeds several hundred dollars, it might make sense to look at replacement instead—depending on the age and condition of the rest of the appliance.
- ***High energy usage.*** A 10-year-old washer may cost you $135 more in energy costs annually than a newer ENERGY STAR® model.

Shopping tips

When evaluating a new washer, look closely at these features:

- ***Sizing.*** Select the size of your washer based on your family and laundry needs. One that is oversized will lead to running smaller, less-efficient loads or waiting for enough laundry to run a full load.
- ***Top versus front-loading:***
  - Front-loading washers generally use less water than top-loaders, saving both water and energy to heat the water.
  - Front-loaders require less detergent; usually a special High Efficiency (HE) type.
  - Front-loaders spin at a much higher rate of speed (1,000 rpm or higher), wringing much more water out of the clothes. This significantly reduces the energy required to dry the clothes.
  - Front-loaders are frequently gentler on laundry, due to the tumbling action of the clothes, rather than the movement of the agitator in a top-loader.
  - Top-loaders are generally cheaper to purchase, initially; when factoring in energy savings, however, the purchase price will be offset over the life of the appliance.
  - Top-loaders are generally easier to load and unload for many people. Front-loaders, however, can be mounted on stands or have the dryer stacked on top to save floor space.

Why not dry your clothes by hanging them in the basement?

Hanging clothes on lines or racks in the basement—especially in the winter when the house is dry—seems like a logical, energy-saving approach. But caution is appropriate, and here's why:

A typical load of laundry may contain several gallons of moisture. As it leaves the clothing, some of it will move to nearby cool locations (like a basement foundation wall or window) where the vapor will condense.

Because this surface is usually cooler than the surrounding air, evaporation may be gradual—enough to encourage the growth of mold and mildew or cause damage to window frames, etc.

Condensation or frost on walls or windows is a sign of too much moisture in the air; make sure you are not trading small energy savings for a potentially damaging solution.

- ***Efficiency.*** Choose an ENERGY STAR® model with an MEF of 2.0 or greater and a IWF of 4.3 or less. Both MEF and IWF numbers are listed for each model on the ENERGY STAR® website.

When evaluating a new ***dryer***, look closely at these features:

- ***Sizing***. Match the size of your dryer to the size of your washer.
- ***Electric versus gas.*** Although gas dryers may cost slightly more (for similar size and features), your choice may depend on the availability of certain fuels (and their connections) in your home. Other factors, such as health and safety concerns or the environmental effects of different fuels, may also inform your decision.
- ***Features.*** Dryers with sensors evaluate the moisture content of the laundry and reduce drying times. This is far better than using a timed cycle, which may overdry clothing, wasting energy and potentially damaging clothes. Options for temperature settings allow for optimal use with different fabrics. Additional features, such as wrinkle-reducing cycles and drying racks, may not add significantly to energy use, but may be important convenience considerations.
- ***Efficiency.*** An efficient washer (with a high spin rate) will wring most of the water out before you put the clothes in the dryer—reducing drying time and energy use. New ENERGY STAR® standards for dryers require efficiency of at least 20% over standard dryers.

Efficient use

Follow these suggestions to keep your laundry energy usage to the minimum:

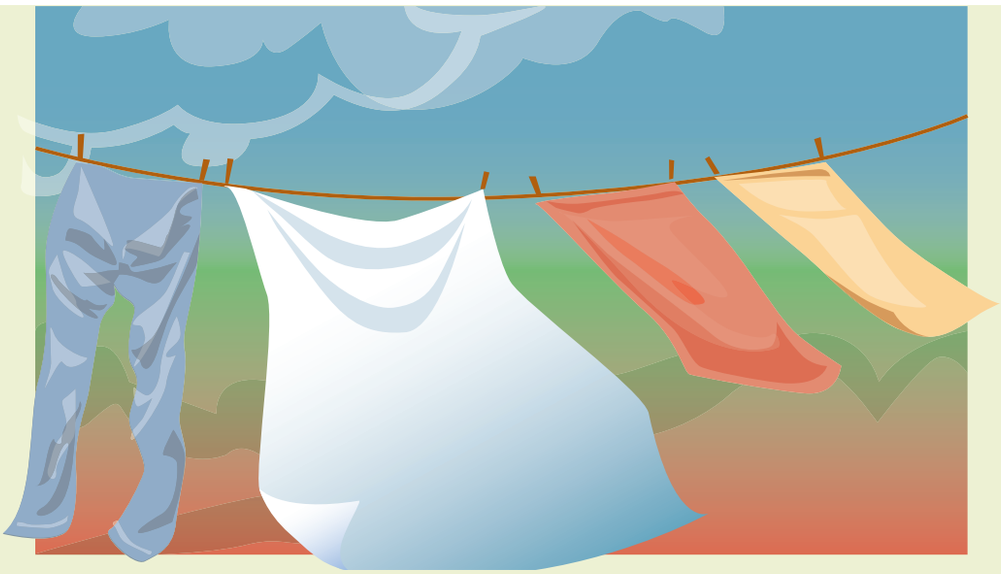
- Wash and dry properly sized loads. Too small, and you may be wasting energy; too large, and you may strain your equipment or get unsatisfactory results.
- Wash laundry in cold water (most detergents are now designed to work well in cold water). Occasionally, some heavily soiled loads may benefit from warm water; hot water washes/rinses should be used for bedding, to reduce allergy issues from dust mites.
- Lower dryer temperature settings to allow for longer "air tumble" times between "heating" times. Along with limiting heat damage to clothes, this will also save some energy; it will lengthen the amount of time to dry a load, however.
- Set your dryer to "less dry" and hang clothes to air-dry the final amount. This method can also reduce wrinkles and eliminate ironing for many clothes. (See sidebar on page 55 for caution about indoor drying.)
- Air-dry clothes outside to reduce dryer usage.

Cooktops, ranges, and microwaves

The energy-related differences between the various ways to cook and bake food usually have very little to do with either the device or its fuel. Although there may be incremental energy savings between different devices, the overall energy used to cook and bake food in most homes is relatively small—$50 to $75 per year on average. There are presently no ENERGY STAR® standards for these appliances.

Shopping tips

The expected life of most ranges and cooktops is 14-20 years; microwaves should last about 10 years. These appliances are usually fairly reliable over their expected life; an estimate for repairs of several hundred dollars might suggest replacement. Many newer models have additional features and



approaches to heating food. When buying range or cooktop replacements, ask about:

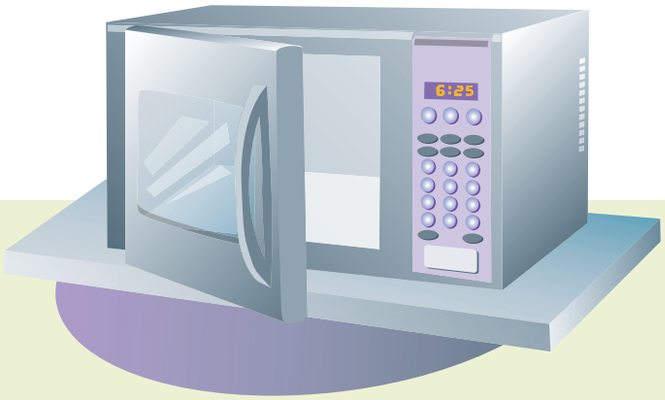
- ***Fuel choice.*** Because the difference in energy use is relatively small, this is usually based on the available fuels and connections in your kitchen. Cooking preferences, indoor air quality, safety, and adding to electric loads may also be factors for some people.
- ***Burner styles.*** Whether coils, smooth-top, enclosed, induction, or halogen, burner styles are largely a matter of personal choice and budget. Some options may heat more quickly; others may leave less residual heat on the cooktop, and thus be safer.
- ***Controls.*** Controls located on the front are much safer than those that require you to reach over burners and hot pans. Newer models have lock-out features to prevent accidental use by children or pets.
- ***Other options.*** Features such as dual timers, convection heating, lighting, warming drawers, intelligent cooktops, etc. may all be important to your cooking styles; again, the energy consequences for most home use are relatively small.

Microwaves are slightly more energy efficient for some cooking tasks, but their main advantage is faster cooking time. The higher the wattage, the less time it takes items to be heated. When selecting a microwave consider the intended uses in order to properly size the unit.

Efficient use

There are a few things you can do to make cooktops, ranges, and microwaves work as efficiently and safely as possible:

- Plan your meals to use the heat from your oven to cook multiple items. Baking a squash? Throw in a couple of potatoes for tomorrow's meal.
- Open oven doors only when necessary; the temperature can drop 30 degrees in just a few seconds.
- Don't place foil on the bottom of a gas oven; it may interfere with the flow of air to the burners.
- Use pots and pans that are sized to fit the burner size on your cooktop. Pans that are too small for the burner allow heat to escape along the sides. Ones that are too large may not distribute the heat evenly across the bottom of the pan.
- When heating food in a microwave, do it in stages, with frequent stirring or turning. Microwaves may not penetrate into the interior of some foods, and thus not kill food-borne bacteria.



Lighting a typical Minnesota household accounts for about 10% of the energy needed to operate the home. There are many opportunities to affect that energy use, such as selecting efficient products and using them appropriately.

Types of lighting

Lighting falls under one of four general categories, based on the use of the space to be illuminated. Well-designed lighting incorporates components of all four types in many rooms within a home.

- ***General.*** Used to provide a basic level of general illumination in a room, ambient lighting can range from a single ceiling fixture to dimmer-controlled wall sconces. Often overlooked, general lighting can establish a mood or complement other lighting options for a room.
- ***Task.*** Designed to give focused and brighter lighting to work spaces, task lighting is used for food preparation, reading, or working on projects. Down lights, track lights, or lamps are common sources of task lighting.
- ***Accent.*** Used to provide illumination for works of art or architectural features, accent lighting can include track lights, indirect lighting, or wall-wash lighting.
- ***Decorative.*** With the focus primarily on the light fixture itself, decorative lighting includes chandeliers and lamps. Because the light provided is usually incidental, decorative lighting frequently is combined with other lighting styles to provide appropriate illumination.

Fixtures

The devices that contain light bulbs are known as fixtures. Although it may not seem obvious at first glance, fixture choices can have a significant effect on the usefulness of lighting—which can also affect energy use.

Surface mount fixtures

Typically found on ceilings or walls, surface-mounted fixtures are attached directly to an electrical box and often controlled by a wall switch. Usually designed to provide general illumination, these fixtures frequently have some type of diffuser that spreads light throughout the room. Surface-mounted fixtures can be as simple as an open porcelain bulb holder or as complex as a dining room chandelier. Depending on the design of the fixture, acceptable bulbs may include any style that distributes light broadly in all directions.

Track lighting, which can be either standard voltage or low voltage, usually uses surface-mounted fixtures. Often used as accent lighting or to illuminate art, track lighting can also be used to provide focused task lighting in kitchens or work areas.

Recessed fixtures

Light fixtures that are recessed into the space above the finished ceiling are commonly known as down lights or can lights. Designed to provide focused light at a particular location, these fixtures are controlled by a wall switch and use reflector bulbs that direct light straight down. Some fixtures may also have partial shields or reflectors that direct the light towards one direction. Because of the risk of heat buildup, it is important to properly match both the size and type of

Saving energy with good lighting design

In the past, flipping a switch would flood a room with light, regardless of what you were going to do in the space.

Today, good lighting design includes options for fixtures, controls, and bulbs—based on how the space will be used.

bulbs to the fixture. Recessed light fixtures that enter the attic space are required to be sealed and insulated to avoid air leakage and fire hazards.

Plug-in fixtures

Light fixtures that are not directly wired to the home electrical system require a cord to plug into an outlet. These include floor, table, and desk lamps as well as specialty lighting like under-cabinet lamps or picture lights.

The flexibility of many plug-in lamp fixtures makes them a good choice for a variety of lighting needs. However, the use of cords (and extension cords) for plug-in lamp fixtures can present hazards. Cords should run along walls wherever possible and should not extend into traffic areas. Extension cords should be rated by Underwriters Laboratories for the intended use. If cords or plugs are cracked or loose, they should not be used until repaired. Using the proper bulb in plug-in fixtures is also important. Heat buildup from an over-sized bulb can be a fire risk.

Bulbs

The standard incandescent light bulb (which has changed very little since Edison's time) was the only real choice for most homes until fairly recently. Today, there are many options, based on performance, lighting designs, and energy use.

Incandescent bulbs

As electrical current passes through the filament in an incandescent bulb, it is heated to a high temperature (400°-500°) which causes it to glow with visible light. Because nearly 90% of the energy input is emitted as non-visible infrared (heat), incandescent bulbs are less efficient than other types that provides the same amount of light. This extra heat can also present a fire hazard in certain types of fixtures. Incandescent bulbs also have a relatively short expected lifetime—between 750-1,000 hours for a general service bulb.

Banned for use?

The Energy Independence and Security Act of 2007 does not actually ban the use of incandescent light bulbs, but it sets efficiency standards that cannot be met by most traditional incandescent bulbs. Importantly, there are many new products that will meet the new standards and provide more efficient and flexible lighting choices.

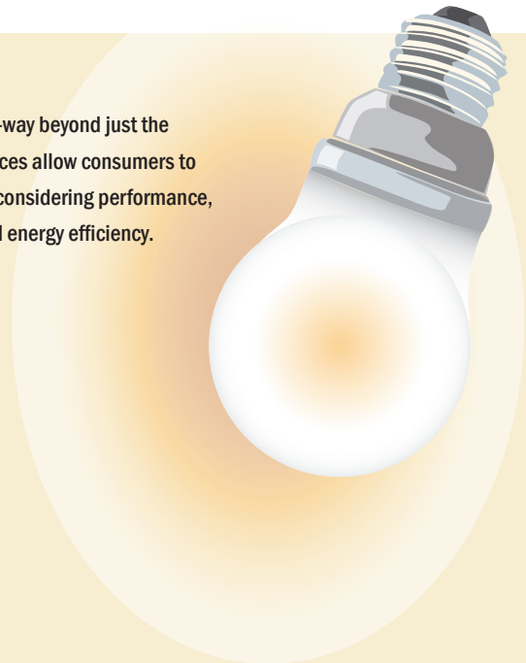
Halogen bulbs

While essentially an incandescent bulb, halogen bulbs are infused with inert halogen gas and have a quartz shell. This allows the bulb to last about three times longer and be about 25% more efficient than a standard incandescent with the same light output. Although commonly used in desk lamps, work lights, and track lighting, halogen bulbs are also available as spot or flood lights for use in recessed fixtures or outdoor lighting. Halogen torchieres (tall floor lamps that direct light towards the ceiling) are also popular; they can present a fire hazard if not properly used, however.

Just like their standard incandescent bulb cousins, halogen bulbs give off a lot of energy in the form of heat. In fact, because the quartz envelope is so much closer to the filament, halogen bulbs can become extremely hot. Most lamps and fixtures that use halogen bulbs are required to have an additional glass cover or shield to reduce fire risks and contain fragments in the event of a bulb failure.

Saving energy with bulbs

Today there are many choices for bulbs—way beyond just the standard incandescent bulb. These choices allow consumers to better meet their lighting needs—while considering performance, bulb life, initial cost, operating cost, and energy efficiency.



Compact fluorescents: improved & efficient

Despite issues with first generation bulbs, the lighting industry has improved CFL performance and now offers many choices for brightness, color, and shape.

CFLs are now available as spots and floods, as decorative candelabra bulbs, as encapsulated bulbs, and as the common "pigtail" style.

Most importantly, ENERGY STAR® labeled bulbs must meet these (and other) standards:

- Provide at least three times more lumens per watt than incandescent bulbs
- Start in less than one second
- Have a rated lifetime of 6,000 hours or greater
- Bulbs with mercury vapor must reach full brightness in less than one minute

Tube fluorescent bulbs

Available since the 1940s, tube fluorescent bulbs are commonly seen today in public buildings, schools, commercial buildings, retail stores—nearly everywhere that lighting is used. Even in residential homes, tube fluorescents are found in basements, garages, and workshops. Valued because of their long life, energy efficiency, and balanced illumination, tube fluorescents are available in a variety of color temperatures and sizes. Recent advancements have replaced older tubes (T-12 with magnetic ballasts) with more efficient tubes (T-8 with electronic ballasts), representing significant energy savings in many buildings.

Compact fluorescent bulbs

The current crop of ENERGY STAR® labeled compact fluorescent light bulbs (CFL) use one-third of the energy and last up to 10 times longer than an incandescent bulb with the same light output. They also operate at cooler temperatures than incandescent bulbs, because they convert more energy into visible light.

Now available in a wide variety of sizes, shapes, and colors, modern CFLs have overcome many of the problems associated with their initial production in the 1990s. Newer bulbs have electronic ballasts which eliminate most of the flickering and slow starting of earlier models, and ENERGY STAR® standards have improved reliability and expected lifetimes considerably.

Along with energy use and estimated life, package labeling now includes information about brightness and light appearance—the best way to determine the appropriateness of a particular product. For many lighting needs, CFL bulbs are an energy-efficient alternative to standard incandescent bulbs.

What about mercury?

All fluorescent bulbs (both tube and CFL) contain small amounts of mercury vapor—between 1 and 5 milligrams in a CFL bulb. For comparison, a mercury thermometer contains 500 milligrams—about the same amount in a dental amalgam. In an unbroken CFL bulb, the mercury is contained; accidental breakage can release the mercury. Although the risks associated with the breakage of a single CFL bulb have been sometimes exaggerated, proper cleanup and disposal is recommended (epa.gov/cfl). Recycling of burned out CFL bulbs is required by law, so that the mercury and other components can be captured and re-used. Check with your county household hazardous waste program, electric utility, or retail store for locations for CFL recycling.

Additionally, because mercury is emitted from coal-fired power plants, anything that reduces electricity usage—including using CFLs—will reduce mercury in the environment.

Light emitting diodes

Also known as Solid State Lighting (SSL), light emitting diodes (LEDs) have been used in electronic devices (like laboratory equipment and calculators) since the 1960s. Advances in recent years have moved LEDs into illumination lighting for retail and commercial businesses—including streetlights, architectural lights, and freezer display cases. Residential lighting options are now entering the marketplace, offering new options for homeowners.

Long life + efficiency

LEDs have several characteristics that make them suitable for many applications in homes and businesses. Roughly equivalent to CFLs in efficiency (as measured by lumens per watt), LEDs have a clear advantage when it comes to estimated lifetimes, which makes them a good choice for locations where bulb changeouts are either difficult or costly. Additionally, LEDs can deliver bright light in a more tightly focused area, making them very suitable for task lighting and directional accent or decorative lighting. LEDs also contain no mercury, but must still be properly disposed at the end of their life. Manufacturers are presently offering

a growing selection of products to meet specific lighting needs, including general illumination options that spread and diffuse the LED light more effectively and warmer colors that match incandescent bulbs. Note: Although many LEDs are dimmable, it is important to check the packaging to be certain of compatibility with your dimmer switch.

Choosing the right bulb

Light bulb options used to be simple—and limited. Residential choices were between incandescents and tube fluorescents; shops, basements, and laundry rooms got the fluorescents and everywhere else the incandescents. The only thing to decide was how many watts you needed.

What about watts?

Watts are a measurement of energy usage that became a convenient shorthand for describing the brightness of an incandescent bulb. Today, with so many types of bulbs to choose from, knowing the wattage of a bulb tells us little about other important characteristics: brightness, color temperature, lifetime, or environmental impact. As consumers, we need to change how we evaluate light bulbs to ensure we match our lighting needs with the proper bulbs and fixtures.

*Lumens: the **real** measure of brightness*

The lumen is a measure of the brightness of light as perceived by the human eye. It is measured independently of the type of bulb

LEDs: new options for home lighting

Some of the first LED products available for home use included reading lights and holiday lighting. Task lighting—in the form of spot bulbs and "under counter" fixtures—capitalize on the directional nature and brightness of LED lights.

The current generation of LED bulbs include improvements in styles, brightness, color temperature, and efficiency—along with moderating prices. New products will continue to provide expanding options for consumers.

Light bulb comparisons

The table below illustrates differences in cost, efficiency, and environmental concerns for selected light bulbs; different products may have different characteristics. Electricity costs are based on current statewide average, not projected costs. Bulbs selected for comparison are currently available retail products. Watts, efficiency, estimated bulb life, and retail prices are from retailers/manufacturers. Numbers have been rounded for clarity. Actual performance will vary.

	Incandescent	Halogen	CFL	LED
Watts	60	43	13	11
Lumens per watt	14	17	65	76
Dimmable	yes	yes	maybe	yes
Est. life in hours	1,500	1,000	10,000	25,000
Est. life in years	1	0.9	9	23
Purchase price	$0.84	$1.81	$1.20	$9.97
23 yr operating cost[1]	$179	$163	$39	$40
# of bulbs for 23 yr[2]	17	25	3	1
23 yr CO_2 emissions[3]	1,900 lbs.	1,400 lbs.	420 lbs.	360 lbs.
Proper disposal	no special requirements	no special requirements	recycle	recycle

[1] *Cost to keep a bulb operating 3 hrs/day at 11¢/kWh for 23 years (the estimated life of the longest-lasting bulb) plus the cost of needed replacement bulbs.*

[2] *Number of bulbs required over 23 years, operating at 3 hours per day, based on estimated life of bulbs.*

[3] *Emissions per year x 23. Based on 1.3 lbs. CO_2 per kWh (MN avg) for 3 hours/day of operation.*

Efficiency: Lumens per watt

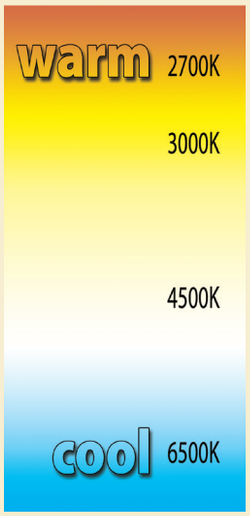
Although any low wattage bulb will deliver energy savings, the only really accurate comparison is how much light (lumens) you get for a specific amount of energy (watts). Presently, CFL and LED bulbs offer the highest efficiency options, with most delivering over 60 lumens per watt—compared with under 14 lumens per watt for incandescent bulbs.

Look for the label!

Choosing bulbs that fit your needs—whether for mood lighting, reading, or detail work—has never been easier. All bulb packaging now includes information on color appearance, brightness, efficiency, and estimated life.

Lighting Facts Per Bulb

Brightness	**500 lumens**
Estimated Yearly Energy Cost	**$0.90**
Based on 3 hrs/day, 11¢/kWh	
Cost depends on rates and use	
Life	
Based on 3 hrs/day	**22.8 years**
Light Appearance	
Warm — Cool	
2200 K	
Energy Used	**7.5 watts**



or the bulb's wattage and provides a more accurate view of how we actually see the illumination. A typical 60-watt incandescent bulb provides about the same amount of lumens as a 13-watt CFL, for example. The higher the rated lumen output of a bulb the "brighter" the light is. Low-lumen output (under 600) may be best suited for decorative or mood lighting. Higher lumen bulbs (over 2,000) may work best for task lighting, especially if the bulbs are directional, such as a spotlight.

Color temperature makes a big difference

All light bulbs emit different frequencies (or colors) of light, depending on the type of bulb, materials used in the manufacturing, and coatings on the inside of the glass. The human eye perceives redder colors as "warmer" and thus more natural for general illumination; bluer or "cooler" colors are perceived as providing sharper detail, well-suited for task lighting.

Somewhat confusingly, the lower the color temperature (measured in degrees kelvin or "K") the warmer the light. Incandescents are typically in the range of 2,700K to 3,300K; fluorescent bulbs can range from 2,700K to "bright-white" bulbs of 5,000K. Halogens may have color temperatures of 3,500K to 6,500K and LEDs are now available with color temperatures ranging from warm 2,700K to cool 6,000K. Choose the color temperature best suited for your use.

Labels make it easier to choose

Thanks to labeling requirements from the Department of Energy and the Federal Trade Commission, choosing light bulbs based on lumens, color temperature, and efficiency is now considerably easier. These labels also include information on estimated annual energy costs, estimated lifetime, disposal requirements, and whether the bulb meets ENERGY STAR® standards. When shopping for light bulbs, consumers can more easily compare characteristics between several bulbs, and make choices to best fit their needs.

Lighting controls

Managing when lights are on and at what level of output is an important way to reduce energy use for lighting. Manually operating switches is the easiest way to control lighting in many situations. Simply turning off a light when leaving a room is efficient and simple. It does, however, rely on one important—and not always reliable—factor: human behavior. In some situations, controlling lighting automatically will not only save energy and money, it can also provide safety and convenience. Lighting control options include dimmers, timers, and motion detectors.

Dimmer switches

A typical dimmer control switch reduces the electrical current to a light fixture, reducing light output and saving energy. Traditionally used with incandescent bulbs, dimmers will also work with certain LED bulbs (some older dimmer switches may not work well with some LED bulbs; check with the manufacturer to ensure compatability). Some CFL bulbs are also capable

of operating with a dimmer switch, but the effect is more like that of a three-way bulb: light levels "jump" from high to medium to low to off. Bulbs that are not designed to be used with a dimmer may burn out prematurely or overheat. Check the packaging or manufacturer to avoid performance or safety problems.

Timers

Many devices, including lighting, can be controlled with a timer. Having selected lights come on when occupants arrive home and off at bedtime, for instance, can provide convenience and safety. Security concerns can be addressed by having lights come on when on vacation, as well. The timer avoids the energy wasted from having lights and devices on over long periods of time.

Newer electronic timers can be plugged into a wall outlet and lamps, radios, computers, etc. can then be plugged into the timer. Entering start and stop times for each day of the week can provide a customized operating schedule.

Motion detectors

In locations where light is needed but the switch is not conveniently located, a motion detector switch can provide a good alternative to leaving a light on all night. Lights outside front and back door entrances or driveways near garages can be set to come on at night when movement is detected and turn off in a set amount of time.

Outdoor motion detector fixtures also provide security and safety, warning of intruders and lighting walkways and steps. The sensitivity and range of these light fixtures should be adjusted so that they are not triggered by small animals or wind-blown trees. Remember to select bulbs that are specifically designed for outdoor use. Many CFLs may light slowly or not at all in cold temperatures; LEDs may be a good choice because of brightness and long life.

Motion detector switches can also be used inside of buildings in areas that are occupied frequently or that have awkward switch locations. A motion switch in a bathroom or basement stairway can operate lights only when someone is present, for example.

Occupancy sensor switch

More commonly seen in public restrooms and commercial buildings, occupancy switches are also available for home use. They are particularly useful in locations where the switch is inconveniently located—at the far end of a hallway or stairway—or where lights are left on for safety or security—in a garage or basement.

Although electronic devices like TVs, DVD players, and computers consume a relatively small percentage of the energy to operate a typical Minnesota household, it may be possible to cut electricity use for home electronics in half—without much effort.

Buy ENERGY STAR®

The *best* way to save energy with electronics is to always replace and upgrade with ENERGY STAR® products. ENERGY STAR® televisions, for example, are 25% more efficient than conventional models and audio/video equipment is up to 60% more efficient. Until you replace, there are some things you can do to reduce energy use in existing equipment, however:

Home entertainment equipment

Televisions, CD and DVD players, cable boxes, stereo receivers, and video gaming systems can use a lot of electricity, even when they appear to be off. Some older TVs, for example, can use up to 40% of the full "on" power when in stand-by mode.

The cheapest way to reduce electricity that is being used by these devices is to unplug them when you don't need them. No additional purchases or special tools are required—just a willingness to be vigilant. Controlling them with a convenient outlet strip can make it easier; a "smart" outlet strip will turn off peripherals (DVD players, game systems) when a primary device (TV) is turned off. Because some devices may require re-programming, you may need to be selective about what you turn off.

Computers and peripherals

A recent study conducted by the Energy Center of Wisconsin indicated that up to 80% of the computers in the study did not have sleep/hibernate enabled. Many people mistakenly believed their computers were in sleep mode because their *monitors* were asleep; in fact, the settings had not been enabled on the computer. Enabling these features can save up to 300 kWh of electricity every year.

A simple trip to your control panel settings for power management will allow you to configure your system to reduce electricity use. Computers that are asleep will still receive updates and be available for other activities (like video streaming to your TV). Peripherals (printers, modems, scanners, etc.) can be controlled by turning off, unplugging, or using a smart outlet strip.

Computers

Adjusting the power management settings for your computer can save up to 300 kWh of electricity a year. When upgrading, purchase ENERGY STAR® computers, monitors, and peripherals.

Chargers

Most of us have numerous devices that have rechargeable batteries: mobile phones, flashlights, power tools, etc. Even though the amount of power used by each of these may seem insignificant, they may continue to draw small amounts of electricity, even when fully charged and the device is disconnected.

Fortunately, there is an easy way to curb this wasted electricity: charging stations. An inexpensive timer can be set to operate for an hour or two at night. Plug an outlet strip into the timer and the devices to be charged into the outlet strip. If located conveniently (kitchen or bedroom for mobile phones, basement for tools), it becomes easy to keep devices fully charged with minimal wasted electricity.

The following resources should get you on the way to making energy-saving improvements in your home. Remember, whether doing the work yourself or hiring a contractor, it is important that you have a good understanding of the options and opportunities available. This checklist will help you make the best choices for your home and budget:

Prework inspection

An independent energy assessment or home performance review is an essential first step to evaluating how your house is currently operating. Proper diagnosis (from someone who is not selling specific products or services) can lead to energy-saving suggestions based on actual measurements and analysis—not on speculation or exaggerated claims.

- At minimum, assessments should evaluate mechanical systems, combustion appliances, insulation, and air leakage.
- Recommended tests include a blower door reading, a combustion appliance analysis, and an infrared scan.
- Local utility or community energy organizations can provide an energy assessment or home performance review. Contact your local gas or electric utility to learn where to get an energy assessment.

Education and research

Once you have a report in hand with specific recommendations, it is time to learn a little more about your options. Information is available from many sources—the task is finding what is trustworthy and useful.

- ***Government and nonprofit organizations*** provide background on building science, design, and energy conservation and efficiency options. Some provide efficiency data on products, enabling easy comparisons by consumers. Others provide information about specific programs or services, including loans, incentives, and rebate opportunities. Check out:
  energystar.gov
  eere.energy.gov
  dsireusa.org
- ***Utility companies*** offer incentives and rebates for energy-saving products or services that help them reach state-mandated energy conservation goals. In addition, they may have lists

of contractors that they approve to install specific equipment or materials. Contact your utility to learn more.

- ***Manufacturers*** and sellers of energy-related products can provide specific data to help with proper sizing or selection of the correct equipment or materials for your situation. They can also be a source of information about available rebates.
- ***Books, periodicals, and online*** sources offer a plethora of energy-related information and evaluations of products and contractors. Be wary, however, of exaggerated claims or unrealistic expectations. The best information provides a balanced perspective on options including professional, academic, or industry evaluations and customer or media reviews.
- Go to our website ***(mn.gov/commerce)*** and sign up for our e-newsletters on topics ranging from energy efficiency tips to notifications of grants and funding opportunities. We also post information about consumer alerts on specific products or companies.

Selecting a contractor

Choosing a contractor is much like a job interview—and you are the employer. The state of Minnesota, through the Minnesota Department of Labor and Industry, establishes standards and safeguards to help homeowners avoid hiring disreputable or unqualified contractors, and to protect them against sloppy or poor quality construction.

- Check out licensure on contractors you are considering. A licensed contractor has met certain requirements, such as having a principal of the company pass an appropriate examination, taking ongoing continuing education, and having liability and property damage insurance. In addition, hiring a licensed contractor provides you with access to the Contractor Recovery Fund, which can reimburse consumers who suffer financial losses as a result of a contractor's misconduct. The Department of Labor and Industry maintains lists of all licensed contractors and their current status. For more information about contractor licensing or building codes and standards, go to (***dli.mn.gov).***
- If a particular trade specialty requires certification or training, make sure the contractor is in good standing with the certifying organization and current on all required training.
- ***Utility companies*** may have contractors that they recommend who have met certain established standards.
- Contact the ***Better Business Bureau*** to see if there are any complaints or actions against contractors you are considering.
- ***Talk with friends, neighbors,*** and suppliers about who they have worked with and who they would recommend for a project like yours. If possible, look closely at the work that was done and ask questions about how the process went—from initial estimate to final payment.
- ***Ask the contractor for references*** and be sure to contact them! Ask for a customer in your neighborhood or community and with a project similar to yours. Don't be afraid to ask direct questions about everything from punctuality, communications, how customers were treated, satisfaction with work quality, willingness to correct errors, and thoroughness of cleanup.
- Check out ***online consumer rating services*** to learn what others may have to say about particular contractors. Consider getting a subscription to one of the paid services,

which are monitored and which provide rankings and comments from customers. Remember that many satisfied customers don't make comments, so a lack of reports may be a positive indicator, as well.

Bids and contracts

Get at least three bids that meet your minimum requirements:

- Only ***review bids that are in writing*** and include detailed information about the job: scope of the work, materials to be used (manufacturer's numbers, models, colors, sizes, anything else that specifies exactly what you are buying), prices, cleanup and debris removal, and names of subcontractors and suppliers.
- ***Be sure you are getting what you are expecting.*** The lowest bid may not be the best; incomplete or vague bids may not protect your interests. Reconsider bids from contractors who hesitate to provide you with the information you need to make an informed decision.
- ***Don't be misled by "sales" or "deals"*** that are available "for a limited time only." If you feel pressured to sign a contract, you should be cautious. Although there are sometimes time limits on rebates for some materials or equipment, be sure it is not simply a tactic to get you to commit before you are ready. And remember that sometimes "sales" are opportunities to move products that are not selling well.
- The ***contractor should apply for permits*** and is responsible for meeting all building codes and arranging inspections. Also in the bid should be information about timeframes and what will happen if deadlines are not met, as well as the schedule of payments and any holdback clauses for incomplete or substandard work.
- ***Contracts are negotiable,*** legally binding agreements. This means that you have the right to request additions, deletions, or changes in the terms prior to signing. It also means that the contractor can do the same. Both parties have the right to enter into a satisfactory agreement.
- Learn about the ***"Three-Day Cooling Off Law"*** that gives you the right to cancel within 72 hours of signing a contract for work to be done on your home. ***Don't provide a check or down-payment until this period has ended*** and you have had the opportunity to review details, check references, or make other evaluations of the contract or the contractor. Learn more at the Minnesota Attorney General's Office (***ag.state.mn.us).***
- The ***final contract should list everything*** that was included on the initial bid. Over the course of the project, any additional work done (not part of the original contract) must be approved by you with a "change order" that specifies the work and any additional costs to you. If you have not signed the change order, it is not an enforceable part of the contract.
- ***Require lien waivers*** from all suppliers and subcontractors. Anyone who works on your home has the right to attach a lien against your property if they are not paid for their work or materials—regardless of whether you paid the primary contractor. Make delivery of signed lien waivers part of the initial contract, and do not make any final payments until you receive them from all subcontractors and suppliers.
- ***Before making final payment,*** make sure everything is completed, including all inspections and cleanup. If you are unsure that everything is done to your satisfaction, ask for a day or so to inspect before making the final payment.

Minnesota Department of
Commerce
Division of Energy Resources

Home Energy Guide

85 7th Place East, Suite 500

Saint Paul, MN 55101-2198

mn.gov/commerce