HOME ENERGY GUIDE

TECHNIQUES TACTICS & TIPS

Construction details that go into a high quality, energy efficient home

Ensuring indoor air quality and moisture control

Questions to ask the builder

Bibliography

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New Homes

Minnesota Department of Commerce Energy Information Center

A new home is the most important purchase most of us will make in our lifetime. When we buy a new home, we want to accomplish several goals, all of them critical to our well-being.

- **We want our new home to provide a comfortable and healthy environment.**
- **We want our home to be efficient and economical in its operating expenses, free of exorbitant energy bills, costly repairs, and other maintenance costs that could have been prevented during construction.**
- **We want our new home to be durable, providing good return on our financial investment when it comes time to sell.**

An energy efficient home is designed to accomplish these goals. It is built on the principles of building science, which recognize that the home is a system consisting of the building structure, the mechanical systems, and the occupants. Over the past two decades, studies of cold climate housing have taught us how these three elements interact, and how the new home and its mechanical systems should be designed to achieve the goals described above. We know, for example, that air tightness increases energy efficiency, comfort, and durability at the same time it requires that outdoor air be brought in to provide healthy indoor air and control moisture. The amount of outdoor air required depends on the number of human occupants, their activities, the location of the home (whether the site is moist or dry), and the kinds of mechanical systems in the house.

This guide is designed to help buyers of new homes understand these basic building science principles and how they affect construction details and the selection of heating, ventilating, and other mechanical systems. It gives new home buyers the information they need to discuss intelligently with the builder the various options for achieving an efficient, durable, and healthy home. Finally, it helps them understand the importance of the home owner's role in furnishing, maintaining, and operating such a home.

Essential Components of an Energy Efficient Home

Three important characteristics distinguish an energy efficient, high quality home: lower energy use, moisture control, and indoor air quality control. These qualities are interrelated. To ensure that all three qualities are present, the new home requires several key components, and these, in turn, require attention to construction details. The components are described below. Discuss them and the construction techniques used to implement them with your builder. Also ask about having a blower door test performed on the newly constructed home to verify air tightness. More information on the various components of an energy efficient home is available in the books and materials listed in the bibliography.

New Home Warranties

Minnesota law requires builders to warrant that the new home will be:

- Free of major construction defects for 10 years. "Major construction defect" means damage affecting the stability and safety of the dwelling. It does not include damage caused by flood, earthquake, or other natural disaster.
- Free for two years from mechanical defects caused by faulty installation of plumbing, electrical, heating, and cooling systems.
- Free for one year from defects caused by faulty workmanship and defective materials.

Some builders enroll in special new home warranty and insurance plans that cover liability for major structural defects. Although the cost of these plans can add to the cost of the home, they are a protection to the consumer and are especially helpful to the new builder in establishing credibility.

Full coverage, optimal thermal insulation

In Minnesota, with its long and cold winters, heating accounts for the major portion of a home's annual energy use. Keeping the same space cool in summer also accounts for a significant – and increasing – portion of home energy use, as air conditioning becomes more widespread. An energy efficient home, therefore, relies on having an outer structure – or thermal envelope – that is tight and well insulated, that reduces air flow and heat transfer between the indoors and outdoors in both summer and winter.

Thermal insulation reduces heat transfer. The ability of insulation to resist heat flow is expressed in terms of R-value: the higher the number the greater the resistance. The R-value of insulation varies according to the thickness of insulation and its material. The Minnesota energy code establishes minimum R- values for foundation walls, exterior walls, and the ceiling/attic floor, but various methods and techniques are available for easily achieving higher than minimum R-values. Some of these options are described below; talk to your builder about these or other ways to achieve optimal thermal insulation.

- On foundation walls, the Energy Information Center recommends at least an R-10. A common practice for achieving a minimum R-5 is to place rigid insulation on either the interior or exterior of the foundation walls. An easy way to increase this R-value to 10 is to install additional insulation on the interior side. If the foundation is concrete or masonry block, builders often construct an inner stud wall which is fitted with batt insulation, or they apply foam plastic insulation right to the concrete wall and cover it with sheet rock.
- On walls: Adding rigid insulation over an insulated frame wall built with the industry standard 2 x 6 inch studs increases the minimum 19 R-value to a recommended 24. Discuss this option with your builder.
- On ceilings/ attic floor: To increase the R-value beyond the required 38 minimum, simply add more insulation. For vaulted ceilings, increase the framing depth to allow for more insulation or install foam sheathing on the underside of the vault.

Full coverage is as important as the insulation R-value. Any part of the house that is heated should be separated from the unheated space by an insulation barrier. Some areas needing special attention include:

- Basement floor. An uninsulated floor is cold and may be damp; an insulated floor is warm and dry. The Energy Information Center strongly recommends insulating the basement floor. A one-inch thick rigid insulation, separated from the slab by a few inches of gravel, can be used. Some heating systems use the basement slab or sand underneath the slab for heat storage. In this case, extra insulation is strongly recommended: two-inch thick rigid insulation surrounding the heat storage system is recommended.
- Crawl spaces beneath heated spaces. To control moisture, a polyethylene moisture barrier should be placed over the entire ground and extended up four to six inches on the crawl space walls and sealed to the walls. The walls of the crawl space can be insulated with batts or with rigid insulation placed either on the exterior or interior of the walls (See Figure 1).
- Attic insulation should extend to the outer edge of the outside wall. (An energy truss allows a full depth of insulation to extend to the outside of the wall. See Figure 6.)
- The rim joist where the exterior framing meets the floor joists is a critical area to insulate and air seal, and it is often a major source of heat loss. One way to handle the problem is to first seal the rim joist against air leaks and then insert pieces of rigid insulation between the joists, covering them with sheet rock to meet fire protection standards (See Figure 2). The rim joist can also be insulated on the exterior. Discuss this with your builder.
- Other problem areas – cathedral ceilings, floor overhangs, and split level homes – are described in greater detail in the insets in this guide.

Continuous, interior side air barrier and vapor retarder

Insulation resists heat transfer, but it only slows – does not stop – air movement. Warm air moving through the insulation results in heat loss in winter and unwanted heat gain in summer, increasing year-round energy costs.

More important than the heat loss, however, is the moisture that the warm air carries into the insulation and onto the building framework. Moisture substantially reduces the effectiveness of insulation and also can result in mildew and mold growth and rot of building materials.

Leaking air is also a major cause of ice dams on roof eaves. Warm air leaking up into the unheated attic through electrical openings and other gaps in the air barrier creates warm spots on the roof, starting the snow melt that eventually leads to damaging ice buildup along the eaves.

Movement of warm air from the heated space into the building envelope is the largest potential source of heat loss and moisture problems, and for this reason a continuous air barrier must be installed on the warm or interior side of the insulation. Since moisture can also penetrate by diffusion, a vapor retarder must be installed on the interior side of the insulation. In most new homes, the air barrier and vapor retarder are one and the same: a polyethylene sheet installed on ceilings and walls. An alternative to this standard air-vapor retarder is the airtight drywall approach (ADA). ADA uses the drywall itself, along with caulking, sealants, adhesives, and gaskets, in various combinations, to achieve the required air barrier. A vapor retarder is still required. This can take the form of a coat of vapor retarder paint or a foil backing applied to the drywall, or most commonly it can be a separate polyethylene sheet.

The critical requirement of the air barrier/vapor retarder is that it be continuous; any breaks result in loss of heated moist air and moisture penetration into the building envelope. Providing continuous coverage with an air barrier/vapor retarder requires attention to details. Electric wiring, plumbing, and other penetrations into the air barrier/vapor retarder are inevitable. The solution is to seal all these openings, using either caulks and foams, gaskets and adhesives, blocking and tapes, or all of these, depending on the size and location of the penetrations. Special attention must be paid to ensure that air sealing occurs at each step of construction. Discuss these details of construction with your builder and ask that a plan be developed to ensure sealing the air barrier/vapor retarder. Discuss the builder's quality control program to ensure sealing of the air barrier. Mention specifically the following areas:

- Areas difficult to insulate, described in the section above and also in the "Design Details" insets in this guide. These areas are also difficult to protect with a sealed air barrier.
- Electrical, plumbing, and telecommunication outlets and other penetrations into the exterior wall and ceiling air barrier.
- Tubs and showers located on exterior walls.
- Fireplace enclosures.
- Recessed light fixtures. These are a major source of air leaks. Talk with the builder about the importance of inspections or other quality control measures to ensure air sealing.
- Ductwork. (It is preferable to have all ductwork run inside the insulated envelope and sealed throughout.)
- Air leakage from the garage. Ask your builder how air from the garage will be prevented from leaking into the home.

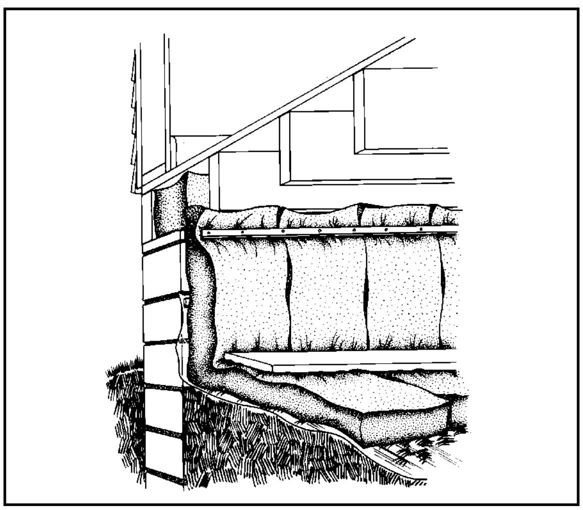

Figure 1
To control moisture in a crawl space, a polyethylene moisture barrier should be placed over the entire ground and extended up at least four to six inches on the crawl space walls and sealed to the walls.

A New State Energy Code

Effective April 15, 2000, new energy code rules go into effect as part of the state building code. The new code incorporates the principle of "build tight and ventilate right." It recognizes that the home is a system, consisting of the building structure, the mechanical systems, and the occupants. The new code takes into account the need for air tightness to ensure comfort and energy efficiency, and also the need for mechanical ventilation to control moisture problems and provide proper amounts of fresh air for the occupants.

The new standards give Minnesota the most advanced energy code in the nation. Considerable effort is required to fully and effectively implement the code, and new home buyers are advised to consult with their builder and work out a plan for informing all subcontractors of the construction details required.

New home buyers should also be aware that they have many options for going beyond code requirements and achieving even higher levels of energy efficiency, comfort, and durability. Many of these options are described in this guide.

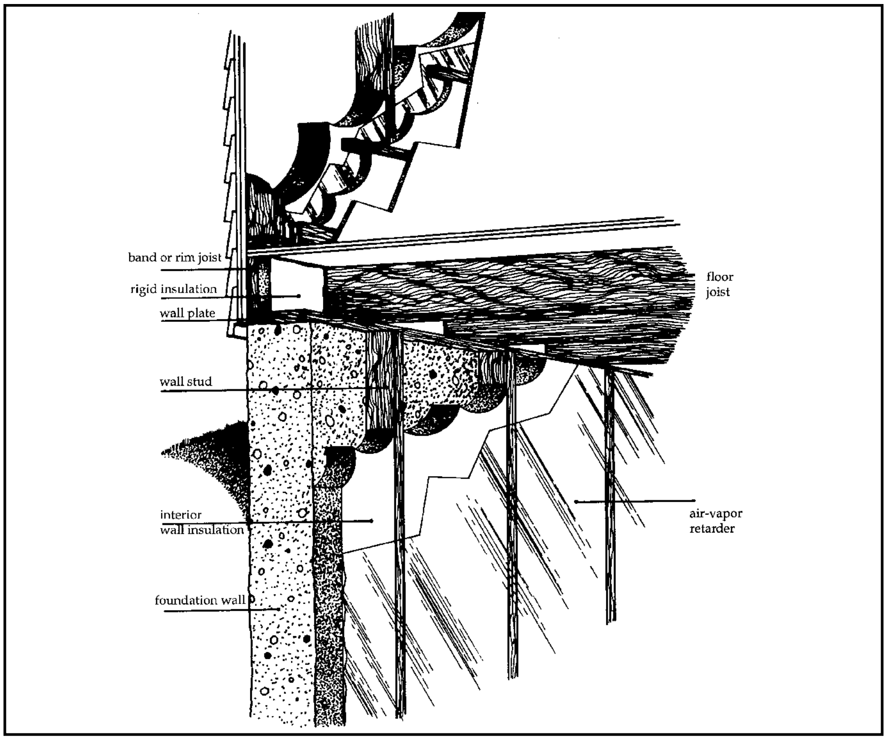

Figure 2

To maintain a continuous air-barrier and vapor retarder at the basement/first floor juncture, the air barrier/vapor retarder covering the inner walls is sealed to the basement wall plate and first floor sillplate, and pieces of rigid insulation are inserted between the floor/ceiling joists. Cut-away section reveals various wall components.

nfrc CERTIFIED — National Fenestration Rating Council Incorporated

AAA Window Company

Manufacturer stipulates that these ratings were determined in accordance with applicable NFRC procedures.

Energy Rating Factors	Ratings Residential	Ratings Nonresidential	Product Description
U-Factor Determined in Accordance with NFRC 100	0.40	0.38	Model 1000 Casement Low-e = 0.2 0.5" gap Argon Filled
Solar Heat Gain Coefficient Determined in Accordance with NFRC 200	0.65	0.66	
Visible Light Transmittance Determined in Accordance with NFRC 300 & 301	0.71	0.71	

NFRC ratings are determined for a fixed set of environmental conditions and specific product sizes and may not be appropriate for directly determining seasonal energy performance. For additional information contact:

Figure 3

Look for the NFRC label providing information on the U-value rating of the window unit. Within a few years, most doors also should carry this rating.

Continuous exterior side air barrier

Insulation and the building framework must also be protected from exterior wind and water. A number of methods and materials can be used, including building sheathings (including some rigid foam insulations) that are impervious to water and air and a sheet of flexible material resistant to water and wind penetration that is placed around the exterior of the building between the sheathing and siding. Some products/materials can serve multiple purposes. A spray foam insulation, for example, may serve as insulation, an exterior air barrier, and an interior air barrier as well.

A separate air barrier is especially critical at the top of exterior walls, where the attic/ceiling insulation extends to the outer edge of the wall frame. Install air chutes or baffles and wind wash barriers at soffit vents to prevent air from penetrating the insulation (see Figure 6).

Energy efficient and condensation resistant windows

Window thermal performance has improved dramatically in recent years. Low-e coatings on glass panes, gas fillings and insulating spacers between panes, and improved framing materials all reduce heat loss in winter and heat gain in summer. In addition to increased comfort and reduced energy loss, a further advantage of these high performance windows is less moisture condensation: greater insulating ability results in a warmer temperature for the windows' indoor surface, resulting in less condensation.

In selecting windows for your new home, look for the label with the National Fenestration Rating Council (NFRC) U-value (or the equivalent for imported windows). The lower the U-value the better the insulating ability. The NFRC U-value rating is on the whole window unit – glass panes and frame – and this is an important distinction. A double-paned window with low-e coatings and gas fillings, for example, might have a center-of-glass U-value of 0.25, but an overall U-value of only 0.34.

Air tightness is another characteristic of an energy efficient window. Make sure the window has durable weatherstripping. Window manufacturers provide results of standard air infiltration tests. The Minnesota energy code sets a maximum infiltration rate of 0.37 cubic feet per minute per linear foot of sash crack (where the sash meets the stationary frame).

Window style or design is not a major factor in efficiency.

Window installation is still another important factor in energy efficiency. Even the highest quality window loses effectiveness if there is heavy air infiltration between the rough framing and the window. Simply stuffing fiberglass into this area is not adequate. Sealing the gap between the rough opening and the window is critical.

- Make sure the builder sizes the rough opening large enough to allow for installing an airtight seal between the window frame and the rough opening.
- Discuss with your builder the various techniques that can be used to achieve quality installation, including an airtight seal and the kind of quality control measures the builder uses to ensure this seal.

Doors also have improved in efficiency; metal and fiberglass doors with cores of insulation now account for about half of all doors in newly constructed homes. Metal and fiberglass doors provide better insulation and security than patio sliding or French doors. Glass patio doors have considerably less insulating value than insulated wood or steel doors. If you plan to have glass doors, ask your builder to use doors that have an NFRC low U-value rating. The NFRC rating for doors began only recently, but within a few years most doors should carry this rating.

Air tightness is as important for doors as for windows. Key factors are good quality weatherstripping and careful sealing of the wall air barrier/vapor retarder to a polyethylene strip wrapped around the door frame. Ask your builder about cold weather performance of the weatherstripping.

Effective ground moisture/soil gas control

Except for structural errors, moisture damage is the nation's leading cause of problems in buildings. And in Minnesota, these moisture problems often begin with a damp or wet basement. Studies show that 10 gallons or more of water vapor per day can evaporate into a house through the basement walls and floors.

The Energy Information Center recommends the following measures:

- The first and perhaps most important step is to select an appropriate building site. A site with a high water table presents substantial obstacles to building and maintaining a dry basement.
- The state building code requires that landscaping be appropriately graded to direct rain water and melting snow away from the foundation. Because the backfill always seems to settle after a year or two, it is important to start with a generous slope: The Energy Information Center recommends at least six inches over the first ten feet from the foundation wall.
- A high quality, durable coating – termed waterproofing – should be applied on the below grade portion of foundation walls. This provides better protection from moisture penetration than the building code's minimum requirement of a dampproof coating.
- Use gravel as backfill around the foundation. Cover it with a low permeability soil or hard surface to divert runoff away from the foundation. Porous backfill gravel or sand should be used against the foundation walls to promote drainage to a channel of coarse rock or drainage tile located outside the foundation footing. A drainage mat product can be used in place of – or in addition to – the backfill gravel or sand. Drainage mats made of corrugated fiber or plastic material create a clear drainage path directing water to the drain tile.
- The concrete slab floor should be poured on top of three to four inches of washed aggregate, with a sheet of polyethylene underlying the aggregate. Insulating under the aggregate with rigid insulation replaces the need for the polyethylene sheet.
- Heated slabs, with heat pipes or cables either embedded in or below slabs, should be protected on the sides and bottom by R-10 insulation.
- Heating system ducts should not be installed in the ground below a slab. In an energy efficient home, it can be appropriate to locate heating duct outlets on interior walls.

Design Details: Skylights

Skylights are a weak area in the thermal envelope; their insulation value is low and they create breaks in the air barrier. Their location at the top of the thermal envelope makes condensation problems and potential air leaks even more serious. Care must be taken to install the skylight so that it is sealed tightly to the air barrier/vapor retarder. Designing and installing the skylight so that snow is shed readily helps prevent problems with snow melt. Look for skylights with an NFRC overall U-value of 0.55 or less, and a shading coefficient of 0.5 or less.

Design Details: Fireplaces

Open hearth or conventional fireplaces are popular, but since they require large amounts of combustion air, they significantly affect the air supply in the home and make it essential to have only direct vent combustion furnace and appliances. A direct vent gas fireplace is fully compatible with an energy efficient home.

- Many homes in Minnesota are now constructed on a concrete slab (slab-on-grade), with no basement. Avoid placing a forced-air heating system below a slab-on-grade. The Energy Information Center recommends that insulation be placed around the perimeter and beneath the entire concrete slab.

Safe, efficient space heating, cooling, and water heating

Space heating is the prime energy user in a Minnesota home. Reducing this energy use and its cost is the principal reason – along with increased comfort – for building an energy efficient home. An important factor in achieving maximum efficiency is the selection of an efficient heating system.

Combustion heating system. A combustion (fuel burning) furnace or boiler requires air (called combustion air) for proper operation. For this reason, it is extremely important to buy a direct vent (sealed combustion) furnace. This type of furnace brings air from outdoors directly into the combustion chamber without mixing it with indoor air, and it discharges all flue gases directly to the outdoors. This type of furnace does not require a chimney, so you'll have greater freedom in where to place it and also save chimney construction costs. The air tightness of a well insulated home also makes it possible to buy a smaller size furnace than otherwise would be needed. An additional advantage of a forced air heating system is that its ductwork can be used by a central air conditioner.

The Annual Fuel Utilization Efficiency (AFUE) for a furnace is like the miles-per-gallon label on a new car. This rating estimates how much of the fuel used actually goes into heating the home, based on average use. A national efficiency standard for furnaces took effect in 1992, requiring that each furnace have an AFUE of at least 78 percent. This minimum rating is expected to rise in the near future. New efficiency models have AFUE ratings of 90 percent and higher, and the Energy Information Center strongly recommends selecting one of these models for an energy efficient home.

Choosing the appropriate size furnace also is important: oversized furnaces, because they cycle on and off more frequently, are less efficient. Your builder can provide a good estimate of what your annual heating and cooling needs will be.

Annual energy costs also are affected by the amount of electricity a fuel-burning furnace uses to circulate air. Variable rate furnaces use considerably less electricity – as much as 50 percent less – than other forced-air furnaces. Features include microprocessor controls, which automatically adjust air flow to achieve maximum efficiency.

Electric heating systems. Coefficient of Performance (COP) measures the efficiency of electric heating. A COP of 1.0 means that the heat energy the appliance delivers is the same as the electrical energy it uses. Although all electric heating systems operate at nearly 100 percent efficiency and therefore have a COP of at least 1.0, this rating does not take into account the energy used to generate and transmit the electricity.

- Baseboard electric heaters, radiant ceiling and wall panels, in-floor radiant heating, and electric furnaces all operate at 100 percent efficiency (COP 1) and, with the exception of electric furnaces, are easily zoned to provide different levels of heat in different rooms. At current prices of electricity, however, they also are probably more expensive to operate than oil, natural gas, or propane furnaces. In some areas of Minnesota, electric utilities provide discount rates for energy used during off-peak hours (usually later at night and in the early morning). Customers can take advantage of these rates if they have a backup fuel source such as fuel oil or propane or have an electrical thermal storage system. These systems consist of heating elements and some type of heat storage unit (such as rock, water, or ceramic materials).
- Air-source heat pumps extract heat from the air and will not perform well over extended periods of sub-freezing weather; for that reason they are not suitable for the Minnesota climate without a backup system. The heating performance of air-source heat pumps is rated by the Heating Season Performance Factor (HSPF), a ratio of the estimated seasonal heating output by the seasonal power consumption for the average U.S. climate. The HSPF of the more efficient pumps ranges from 7.7 to 10. The Energy Information Center recommends an HSPF of 8.5 or higher. The cooling performance of air-source heat pumps is rated with a Seasonal Energy Efficiency Rating (SEER), with

the more efficient systems having a SEER of 13 or higher.

- A ground-source heat pump appears to be the most practical heat pump for the Minnesota climate. The heating efficiency of ground- or water-source heat pumps is rated by their COP, and their cooling efficiency by their Energy Efficiency Ratio, or EER. The most efficient of these pumps has a COP of 3.4 or higher and an EER of 16 or higher.

Cooling. Just as heating costs are reduced in an energy efficient home, so, too, are cooling costs. Higher insulation levels and increased air tightness of an energy efficient home keep the house cooler in summer as well as warmer in winter. If you decide to cool your house with air conditioning, you can either have a central system to cool the whole house or window or wall units that cool one or more rooms. Split units or high velocity units also are available for homes with hot water or electric heating, but these systems are also more expensive than the standard forced air unit which can use the furnace ductwork. For maximum efficiency, the air conditioner capacity should match the cooling load (it is important not to oversize). On room or wall units, check the Energy Guide label for the energy efficiency ratio (EER): the higher the number the better. The Energy Information Center recommends a rating of 10 or higher. Central air conditioners are rated by Seasonal Energy Efficiency Ratio (SEER) and should be 12 or higher.

Water heating. It is extremely important that a combustion water heater be direct vent (also called sealed combustion) or be the power draft type which exhausts its gases through the side of the house with a fan. Another option is to use a non-combustion water tank that is heated by a boiler.

Selecting an efficient heater is important. Check the yellow and black Energy Guide tag found on all new water heaters. The tag gives the estimated yearly cost of operating the unit and shows how the particular model compares in energy use to similar models. Another important piece of information is how much hot water the tank can provide. The ability of a water heater to meet peak demand for hot water is indicated by its "first hour rating."

Other measures to increase efficiency of the water heater include wrapping insulation around the pipes coming from the heater and wrapping the heater itself in an insulation jacket. The water heater also should be equipped with heat traps to cut down heat losses. Low-flow showerheads and faucet aerators that conserve hot water also reduce energy use for water heating.

An attractive new option for energy efficient homes is to combine water and space heating into a single unit. A number of these systems are on the market. Some appear no different than either a conventional water heater or furnace. Considerable savings in overall equipment costs and overall operating costs are likely.

Managed mechanical ventilation

Healthy indoor air requires a regular admixture of fresh outdoor air. In a cold climate like Minnesota's, this outdoor air cannot reasonably be provided year round by opening windows. A controlled, mechanical ventilation system is required. (Beginning April 15, 2000, a controlled mechanical ventilation system will be required by the state energy code.)

Developments over the past three decades in new home construction, materials, methods, and home furnishings make it even more important to manage indoor air quality with mechanical ventilation. Tighter construction and the prevalence of powerful exhaust equipment such as kitchen range fans and clothes dryers profoundly influence the indoor environment. It is important to remember that the entire home is a system that includes building structure and mechanical systems, and that these interact with each other. The structure and systems are also affected by the number of occupants, their life style, the size of the house, the outdoor climate, and the house site.

How much outdoor air is needed is based mainly on three factors: the volume of the home, the number of people in the home and their activities, and the amount of air exhausted out of the house by fans and other equipment.

Makeup air is the term for air that replaces air exhausted out by fans and other equipment. The amount of makeup air required varies according to the number and power (cubic-feet-per-minute, or cfm) of exhaust equipment and also on whether the furnace and other combustion appli-

Design Details: Overhangs and Split Levels

Two house designs that require special attention to achieve energy efficiency are floor overhangs, or cantilevers, and split levels. These designs create difficulty in maintaining a continuous air barrier. In the case of overhangs, the recommended practice is to fit rigid foam insulation panels between each floor joist cavity and seal at the edges with caulk. For the split level house, a number of special techniques have been devised. Talk with your builder about possible methods to use.

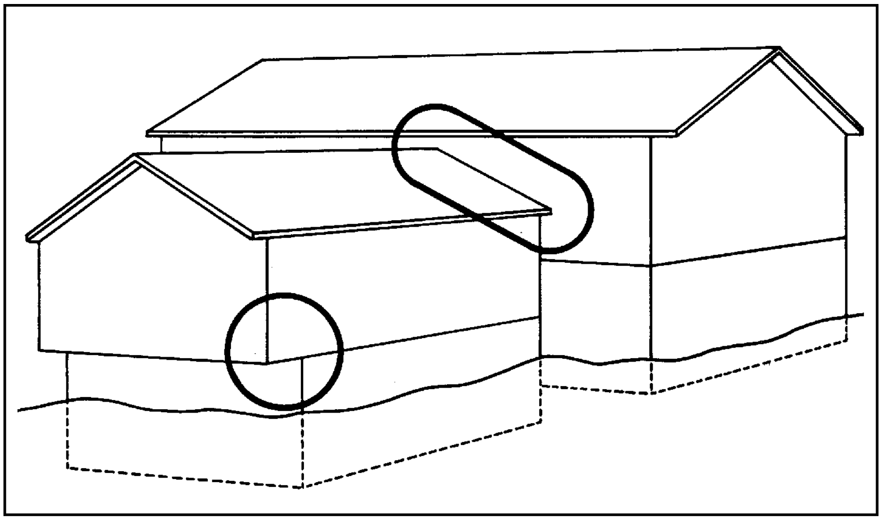

Figure 4

ances in the home are sealed combustion or power vented. In an energy efficient home, which has sealed combustion or power vented type furnace and water heater, the need for makeup air in some cases can be satisfied by passive intake – that is, air which enters without the aid of fans or other mechanical equipment. The Energy Information Center recommends, however, and the new Minnesota energy code in most cases will require, that powered makeup air (air brought in by mechanical means) be provided for clothes dryers with exhaust exceeding 160 cfm, kitchen exhaust fans over 250 cfm, and other exhaust equipment exceeding 100 cfm.

People ventilation. The Energy Information Center recommends, and the Energy Code will require, a base, 24-hour mechanical ventilation capacity of 15 cfm per person, plus 15 cfm for the house, with a minimum rate of 45 cfm. Depending on the volume of the house and the activities of the people inside, supplemental ventilation is required.

Different types of mechanical ventilation systems can provide the necessary outdoor air, as long as the system has the capacity to provide 0.35 air changes per hour to the house, distributed to all habitable rooms. Ask your builder what options you have for ventilating your home.

Whatever system is selected, it is important that the home owner understand the ventilation requirements and operate the system so as to provide the needed amount of fresh air. Although ventilation systems can use the same duct system as the furnace, it is strongly advised that the exhaust air have separate ductwork. If both intake and exhaust use the furnace system, the exhaust air can end up being recirculated rather than replaced with outside air.

During the first months after a home is constructed, the ventilation system should be operated continuously at the highest rate of operation possible to ventilate the extra moisture and gasses emitted from construction materials, carpets, and other new furnishings. After the first year, the ventilation system should be operated whenever the home is occupied. (The only possible exception being those beautiful days when all the windows are opened.)

Below are brief descriptions of some of the ventilation systems available.

- Central heat recovery ventilator (air-to-air heat exchanger). Currently, this is probably the most complete, readily available, and efficient ventilation system available. It consists of an intake fan, exhaust fan, and a duct system. It also has a heat recovery system that reduces indoor heating and cooling loads. This system can be run continuously, or it can be controlled by timers or a dehumidistat. Its major disadvantage is high initial cost.
- Central intake and exhaust fans, with their own duct system, are similar to the heat recovery ventilator without the heat recovery feature. The system also can be run continuously or controlled by a timer or dehumidistat. The initial cost is significantly less than that of a heat recovery ventilator.
- Powered exhaust, powered supply intake. This system has a number of variations, all of which call for some form of mechanical exhaust and supply. In one case a centrally located exhaust fan is installed; in another case spot exhaust fans in the kitchen and bathroom are used along with a whole house exhaust installed in the main living space; still another variation uses a central exhaust-duct system feeding one central fan, installed in the basement or a location away from the living space, that exhausts air from the kitchen, bath, and other selected areas. In all of these cases, air is brought in, with fans or other mechanical equipment, through inlet vents and mixed with household air to warm it and then distributed through the home. All of these systems can be controlled automatically.

Installation recommendations. For all ventilation systems, it is always a good idea to locate exhaust grilles high on walls and run the ducts down the wall and the output from the fan out the rim joist. This avoids breaks in the ceiling air barrier, keeps air from rising through the duct when the system is not running, and prevents condensation from forming inside the duct in the attic and dripping back down through the grille. Minnesota's energy code will require that the ventilation system components be installed to minimize noise and vibration transmission, and also will require written certification that all components of the system are functioning in the manner intended.

Design Details: Tuckunder and Attached Garages

Because of the noxious fumes prevalent in garages, tuckunder and attached garages are required to be completely sealed from the rest of the house. A number of locations are vulnerable, however, to gaps in the air barrier separating the house and garage: the rim joist where the home's floor joists meet the frame of the garage/house wall; door and door frames from the garage into the house; and electric outlets or switches in the garage/house wall. A particularly difficult area occurs in a tuckunder garage where the common wall between the garage and home meets the living area floor/garage ceiling (see illustration below). One solution is to place rigid foam insulation panels vertically between the floor joists, sealing the edge with caulk. Additional problems can be created when pipes and ductwork are installed in the garage ceiling: these openings must be sealed to prevent air leaks, and insulation should be installed around the ductwork and pipes.

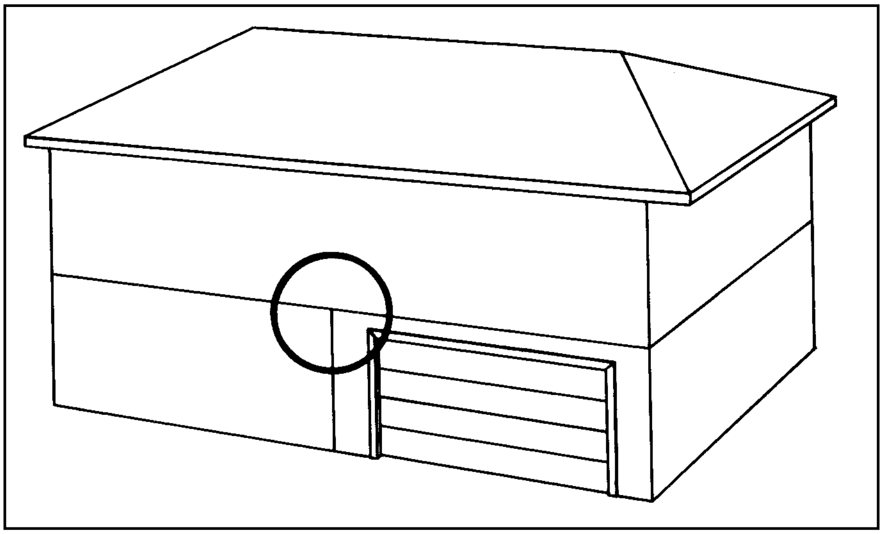

Figure 5

Design Details: Cathedral Ceilings

Builders can use a number of techniques to allow for added insulation in cathedral ceilings. The Energy Information Center recommends two options: the "scissors truss" or supplementing insulated rafters with rigid insulation. The scissors truss allows plenty of room for insulation and ventilation in the space separating the roof and ceiling. If the design does not allow for a scissors truss, roof rafters or truss can be fitted with R-38 batt insulation and an inch of rigid insulation added on the underside of the rafter or truss. Regardless of the method used, the two important features are maintaining a clearance of one or two inches under the roof deck for required ventilation and maintaining a tight air barrier to prevent warm, moist air flow from the living space.

Efficient and safe appliances and lighting

Home appliances and lighting are much more efficient than those of 15 years ago, and efficiency pays. Owning and operating a new appliance or lighting is like buying on the installment plan: the purchase price is only a down payment. The rest of the cost is paid through gas and electric bills, month after month, for as long as the appliance and lighting are used. These monthly energy costs add up. For example, running a refrigerator for 15 to 20 years typically costs three times as much as the purchase price. In the case of lighting, an efficient compact fluorescent lamp may cost more than a standard incandescent bulb, but it pays for itself several times over in energy savings and length of life.

When selecting appliances and lighting, look for the efficiency labels. Energy guide labels list the estimated annual operating cost of the appliance and how the particular model compares in energy use to other similar models. These labels are found on refrigerators, freezers, clothes and dish washers, ranges, and ovens. Efficiency labels also are required on the packaging of general service incandescent bulbs (30 watts or higher), compact fluorescent lamps designed to replace general service incandescent lights, and general service fluorescent lamps. The new labels list the light output (in lumens), the amount of energy used (in watts), and the life of the lamp (in hours).

In addition to checking the efficiency label for an appliance, be aware that other features can increase or decrease energy use. Chest freezers, for example, are typically 15 to 20 percent more efficient than upright freezers because they are better insulated and cold air doesn't spill out when they are opened. Clothes washers with a horizontal axis use much less water than standard top-loading machines, reducing energy use by as much as two-thirds. The Home Energy Guide on Appliances is a good source of information, as well as the publication Most Efficient Appliances (see bibliography).

Low toxicity materials, furnishings

The new home built to the standards described in this guide assures, to a considerable extent, a healthy indoor environment. Installing and operating a mechanical ventilation system and selecting sealed combustion or power vented combustion appliances greatly reduce the threat of carbon monoxide (CO) buildup. Mechanical ventilation combined with other measures to control moisture (i.e. a continuous vapor retarder and air barrier and foundation water proofing and other measures to control ground moisture and gases) reduces the source of mold growth and helps prevent radon entry.

Other indoor pollutants, however, particularly volatile organic compounds (VOCs) such as formaldehyde, can come into the home on products and furnishings. VOCs are chemicals that become a gas at room temperature. They are found in such products as particle board, plywood, paneling, pressed-wood products, and urea formaldehyde foam insulation. Some carpeting, synthetic fabrics, paints, solvents, pesticides, cleaners and disinfectants, air fresheners, and dry cleaned clothing contain VOCs. These sources of VOCs may be too potent to be diluted and dispersed by the ventilation system. The best prevention is to avoid bringing these materials into the home. The new home buyer, therefore, should work closely with the builder to select materials free of these pollutants.

More information on VOCs, radon, and other home pollutants are available from the Minnesota Department of Health, 651-215-0909. Another good source of information is the American Lung Association of Minnesota, 651-227-8014 or 800-642-LUNG.

Costs, Other Considerations

What will it cost?

Estimating the additional costs of incorporating the above components into the new home is difficult. Higher quality probably translates into higher costs, but a builder experienced in energy efficient construction may be able to build your home for a lower cost than a less experienced builder could. Explore other options for reducing the costs; for example, ask your local utility if it offers rebates on more efficient appliances, and ask your lender about energy efficient home mortgages. Remember also that a durable, quality home should have a higher resale value and its maintenance costs should be lower.

Home grounds

Although this guide has focused on home construction, the home site and landscaping also affect home energy use. If your home site offers you the opportunity, you could benefit from solar heating by placing more windows on the south side of the home and fewer on the north. Landscaping with trees and shrubs not only makes your home more beautiful, it can reduce home energy use. The principal points to remember are to shade west- and east-facing windows by planting deciduous trees, avoid planting trees south of windows, and create windbreaks by planting dense evergreens to the north and west of the home. A brochure on landscaping for energy saving is available from the Energy Information Center.

Selecting a builder; questions to ask

Throughout this guide the new home buyer has been advised to ask a number of specific questions regarding the components of an energy efficient home. All of these questions are good to discuss and you may, depending on the response of the builder, decide to select another builder. Below are suggestions for other questions to ask and factors to consider before selecting a particular builder.

- Ask how long the builder and company have been in service, will they provide references, what after-sale services do they offer, and do they provide a guaranteed third-party warranty and what specifically does it cover? (Third-party refers to those outside the company that the builder hires to perform specific jobs.)
- Ask for a description of the features included in the base price, along with a description and cost of options.
- Contracts you sign should clearly spell out what the builder is providing as standard inclusions and what you are paying for as upgrades.
- What kind of quality control does the builder provide for work done?
- Balance price and value. The range of prices in new homes generally reflects differences in location, features, and quality of construction. If a builder's prices seem out-of-line, ask for an explanation. Higher prices should reflect better quality materials, finishing, features, and service.

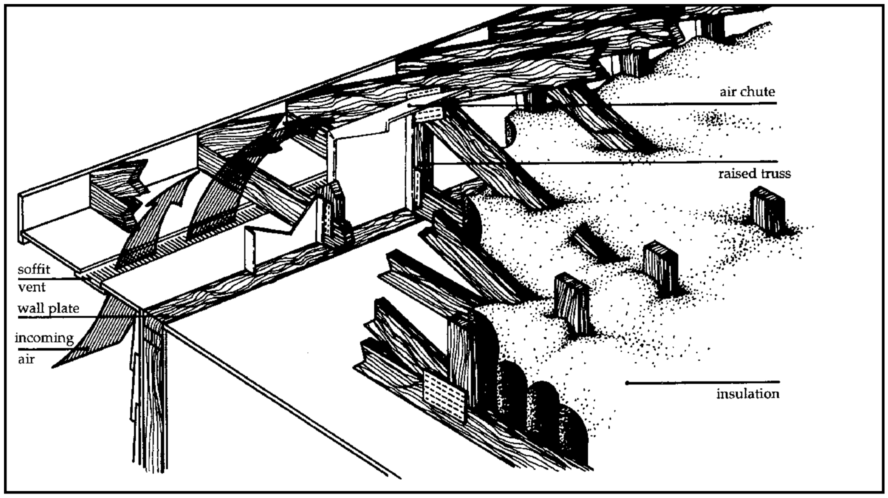

Figure 6
Raised trusses provide room for added insulation to extend to the edge of the attic, covering the wallplate. Air chutes (or baffles) protect insulation from incoming air from soffit vents.

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