Building energy-efficient new houses

You need to plan for an energy-efficient home long before construction begins. The decisions you make on such factors as your home’s site, shape, the building materials to be used, and the solar heating possibilities, will affect its energy efficiency.

Build your house tight

Air leaks reduce a home’s energy efficiency. Air can leak through cracks or holes in walls, ceilings, floors, and around doors and windows. A typical house loses about one-third of its heat through this infiltration (outside air coming into the house) and exfiltration (inside air escaping). A tight house will reduce heat and air movement and be quieter and cleaner. The other two-thirds of heat movement occur by conduction through foundations, floors, walls, ceilings, roofs, windows, and doors.

Good construction techniques cut infiltration, exfiltration, and conduction energy losses. Infiltration and exfiltration losses can be reduced by:

- installing continuous vapor retarders on walls and ceilings,
- caulking any holes or cracks on the inside surfaces of walls and ceilings,
- caulking around windows and door trim on the outside,
- sealing around window and door trim, and electrical outlets on the inside,
- sealing around any pipes or ducts that penetrate the exterior walls,
- weatherstripping windows and doors.

Heat flow in and out of the building from conduction can be reduced with high levels of insulation in the attic, sidewalls, basement walls, and doors. Windows should have a low U-value, and be concentrated on the south for solar gain.

Site selection and orientation

House location influences the amount of energy used in heating and cooling. Ideally, the site should have a good southern exposure for maximum solar gain in the winter, and protection on the north and west from cold winter winds. A site that slopes to the south also offers the potential of building the house into a hillside. Earth-sheltered construction helps protect the house from cold north winds during the winter while offering maximum exposure on the south for solar heating.

Retain existing trees on the building site, and plant additional trees for wind protection in winter and shade in summer. One or two rows of evergreen trees on the north and west sides reduce wind velocity and heat loss from the house. Large deciduous shade trees close to the east, west, and south sides help keep a house cool during the summer. Such trees lose their leaves in the fall and allow solar gain during the winter (Figure 1).

Figure 1. Trees on the north and west can reduce winter wind; deciduous trees on the south provide shade during the summer but let the sun through in the winter.

Orient a rectangular house with the long axis running east and west rather than north and south to promote solar heating gains in the winter and reduce solar gains in the summer (Figure 2). Properly oriented houses, with

Figure 2. Proper orientation of a house and location of the garage can protect the house and offer maximum potential for capturing solar energy.

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correct roof overhang and window placement, make the south glass area a direct gain solar collector during the winter when the sun is low and reduce the impact of the high sun during summer (Figure 3).

Locate an attached garage on the west, north, or north-west corner of a house to provide protection from hot afternoon sun in the summer and cold westerly winds in the winter.

Building shape

The shape of a building determines how much area is exposed to the outdoors through exterior walls and ceilings. To save energy, try to keep this exposed area to a minimum. The most economical house to build and heat is one with a simple square or rectangular floor plan. Exposed surface area increases and so do construction and energy costs when a house has a complex shape.

Types of construction

Most houses in Iowa are built with masonry or wood foundations and wood-frame walls, floors, ceilings, and roofs. Spacing between framing members, type of covering materials, and amount of insulation between framing members varies. Houses that are underground or earth-protected may use masonry materials for most or all building components. Houses also may be built with solid wood walls (logs); additional framing and insulation may or may not be added. Other houses may combine timber framing, masonry, insulated sandwich panels, insulated domes, or other materials.

Consider conduction heat losses as you examine construction materials. **R-value** is a measure of resistance to heat flow through a material or combination of materials. The higher the R-value, the better the insulation capacity or the lower the conduction heat loss. Resistance to heat flow through any building component is calculated by adding the R-values of the different materials used.

Foundations

Most houses in Iowa are built with basements constructed of concrete blocks, poured concrete, or treated wood. Masonry materials have a low insulation value (about R-2 for an 8-inch thick wall). Masonry basement walls must be insulated either on the inside or outside to reduce heat flow. The level of insulation needed decreases from R-20 at ground level to R-10 at basement depth.

Rigid, extruded polystyrene insulation typically is used for external insulation. If a finished interior wall surface is desired in the basement, insulated wood-frame walls may be built on the inside.

Some Iowa homes have a relatively new type of wood foundation called the **Permanent Wood Foundation System**. This wood-frame system uses specially treated lumber and plywood with a unique waterproofing and drainage method. Insulation can be placed between framing members to generate a relatively high R-value.

Exterior walls

In the past few years, the most common exterior wood-frame wall used in house construction featured 2-by-4 lumber framing spaced 16 inches apart, wood siding, ½-inch fiberboard sheathing, 3 ½ inches of blanket insulation, a 4- or 6-mil plastic vapor retarder, and ½-inch gypsum wallboard interior. The total R-value of such a wall is about 14. Wood-frame walls can be made more energy efficient by using different framing modes, by adding additional or better insulating covering materials, or by increasing the amount of insulation between framing members. Currently, a composite R-value of 25 to 30 for exterior walls is a reasonable goal.

The use of wider studs permits incorporation of more insulation in the wall cavity; for example, 2-by-6 studs allow installation of 5 ½- or 6-inch insulation batts between framing members. R-values for such walls typically will range from 22 to 25. The University of Illinois has developed a double-framed, 2-by-4 wall with staggered vertical framing members. This wall system allows even larger amounts of insulation to be incorporated, resulting in an R-value of 30 or more.

Improved (higher R-value per inch) or thicker exterior sheathing materials can be used on any framing mode. Rigid insulation panels made of polystyrene, isocyanurate, or urethane are available. For example, 1-inch thick extruded polystyrene exterior sheathing increases the R-value by 4 or 5 compared to fiberboard sheathing. Special wall bracing is needed at the corners of exterior walls when rigid plastic foam sheathing panels are used. Rigid insulation panels also may be installed under gypsum wallboard on the warm, interior side of exterior
walls. Such materials always should be covered with at least ½-inch gypsum wallboard or a comparable fire-resistant material.

Solid wood walls in log houses must be very thick or include additional insulation to be energy efficient. For example, the R-value per inch of woods typically used in log walls ranges from 1.1 to 1.8. Such a wall would have to be at least 11 inches thick to have an R-value of 20. Masonry walls (brick, poured concrete, or concrete block) also must incorporate substantial added insulation to achieve a recommended R-value.

Installing a vapor retarder on or near the interior surface of exterior walls reduces both air infiltration and penetration by water vapor. A continuous layer of 4- or 6-mil polyethylene plastic typically is installed under interior wall coverings. Seal any holes and avoid any interruptions in this vapor retarder.

To reduce heat loss, minimize the number of electrical outlets on exterior walls. Carefully seal around all outlets and any other penetrations through or into exterior and interior walls.

**Windows and doors**

Substantial heat loss can occur through windows and doors. Glass is a poor insulator; the R-value for a single layer of glass is approximately 1. Total heat loss through windows depends on the location, number, size, and type of windows. A single north or west window in a room could lose more heat than the entire exterior wall.

South facing windows can function as efficient solar collectors and result in a net heat gain during the winter. All other windows are net energy losers during the winter. Whenever possible, concentrate glass on the south, and minimize the number and size of windows on the other walls.

Better windows will increase comfort, reduce winter condensation problems, and reduce both winter and summer energy costs. Install only windows that have an R-value of at least 2. Windows with R-values as high as 9 now are being produced experimentally. Minimize air leakage with proper weatherstripping.

Properly installed, well-fitted shades, drapes, or quilts can reduce heat loss in the winter and heat gain in the summer. Installing tightly-fitted, insulated panels over north, west, and east windows (inside or outside) will further reduce conduction heat losses through windows.

Use insulated doors and storm doors to minimize heat loss through entry doors. Such assemblies typically have R-values of about 10 or 12. Use the minimum number of outside doors consistent with good traffic flow and safety. Avoid door openings on the north and west whenever possible. Consider an air lock or vestibule for exterior entrances.

**Ceilings**

Install sufficient blanket or fill insulation in the ceiling below unheated attics to provide an R-value of at least 38. To ensure a uniform depth of insulation, consider using special roof trusses called “raised-heel” or “energy” trusses that allow more vertical space over the exterior walls (Figure 4). In sloped ceilings, roof members must be wide enough to allow inclusion of enough insulation between the framing members to provide the desired R-value. A layer of rigid insulation also may be added to enhance energy efficiency. Install a continuous vapor retarder above the interior ceiling finish material.

Provide adequate ventilation in unheated attic spaces to remove heat during the summer and moisture during the winter. Install inlet vents at the lower edge of the roof (overhang) and outlet vents at the roof peak. Attics with a ceiling vapor retarder need at least 1 square foot of net free vent area for every 300 square feet of attic floor area. Vents that are screened and louvered should have three times the area to compensate for the obstruction to free flow of air.

**Solar energy**

Solar energy can be used for both space heating and water heating. But active solar systems often are expensive to install. Compare the installation and operating costs to energy savings before purchase. Great care in design, materials, and construction is necessary for success of a solar heating system.

Passive solar options often are attractive, comfortable, and simple. In new homes, the cost of using passive solar heating often is very little more than building the home conventionally. The simplest passive solar heating

![Figure 4. Raised heel trusses give extra room for insulation at the outer edge.](image-url)
system is a window on the south side. As the amount of glazing on the south side increases, extra “thermal storage” should be provided. A variety of technical publications are available to help you, or you may wish to hire a design consultant.

**Heating and cooling systems**

New, high-efficiency heating and cooling systems are available. Install the system that is compatible with the most economical fuel available. Select the correct size for your needs, and purchase a unit that is highly rated and efficient. The extra cost in buying an efficient system generally will be regained through reduced fuel bills. Many heating systems now use two different energy sources; the best combination for you will depend on your situation. For example, some people combine passive solar and wood heat. Others combine a heat pump system with a solar installation. Investigate heating and cooling equipment before signing a contract to build your new house. Make sure your builder knows that you want to select from high-efficiency models.

**Controlling moisture problems**

Water penetration and accumulation must be carefully controlled in new house construction to maximize thermal performance and to prevent costly repairs. When insulating and sealing a house, small details are important. A small area that is not insulated and sealed can lose large amounts of heat. Air leaks can carry moisture into the house framing, where it can condense and lead to discoloring of drywall, paint failures, or wood decay.

Canadian building specialists have developed a unique house construction system, labeled the *Air Tight Drywall Approach*, specifically designed to control moisture problems. Detailed information on this system is available from Energy Extension at Iowa State University.

To ensure clean, healthy air, install a ventilation system in the interior of the house. These systems remove moisture, odors, and other pollutants from the house and replace the tainted air with fresh, outdoor air. Using a ventilator with heat recovery reduces operating costs.

**Energy code**

Iowa now is covered by a model Energy Code which helps ensure that your house will meet minimum energy efficiency standards. However, it may be cost effective to exceed those minimums. Visit with your utility and code officials for the latest copy of the requirements. Select a builder who knows the code requirements and is interested in energy-efficient construction.

**Summary**

Follow these guidelines to build an energy-efficient house.

- Build your house tight.
- Orient the long axis east-west, and place most windows on the south side.
- Use energy-efficient construction methods and materials.
- Thoroughly insulate the house.
- Use energy-efficient heating, cooling, and lighting systems.
- Use fan-forced positive fresh air ventilation to keep the interior smelling fresh and reduce health problems.
- Meet or exceed the minimum energy efficiency standards of Iowa’s Energy Code.

Iowa State University Extension has additional publications to help you build new, or repair or remodel your existing home. For more information, visit your county extension office.