



# Insulation

When homeowners begin to think about soaring energy prices, the first thing that comes to mind is insulation. However, any energy conservation plan to improve home energy efficiency must pay attention to the entire thermal envelope before insulation is added. Improving your home's energy efficiency involves an understanding of the system of components that protect and separate the indoor living space from the outdoor climate. Increasing insulation is only part of the answer. Insulation is a crucial component of the thermal envelope, but it is only one part of an entire system. The thermal envelope system also includes siding, sheathing, vapor and wind barriers, drywall, plaster, and other materials that prevent heat loss through air leaks and keep wind from penetrating the thermal envelope. If any one of these components is deficient, the system is compromised and the thermal insulating capabilities are reduced.

Homes that were built prior to 1970 have little or no insulation. They are prime targets for insulation. Newer homes have adequate levels of insulation as required by the municipal building codes.

## Before you insulate

Three things must be done before insulation is added. First, fresh air must be provided to the occupants by a controlled method (mechanical equipment such as fans or ventilators or by controlled infiltration). A home may be too tight and not provide sufficient fresh air and can lead to respiratory problems such as asthma or allergies due to mold, mildew and exposure to volatile organic compounds emitted from carpeting and building materials, or can cause excessive moisture build up inside the home. Too much moisture can deteriorate building materials, promote mold, and mildew growth. Secondly, all uncontrolled air leaks in the thermal envelope should be sealed. Thirdly, you must prevent moisture accumulation. Moisture control is a major concern associated with installing thermal insulation. The warm air inside your house contains water vapor. If this vapor passes into the insulation and condenses, it can cause significant loss of insulating value, it can cause mold growth, peeling paint, and eventual rotting of structural wood. To guard against moisture problems, use vapor retarders and provide adequate ventilation for the house. If you have a crawl space, you should place a vapor retarder on the ground surface. Vapor retarders are special materials including treated papers, plastic sheets, and metallic foils

that reduce the passage of water vapor. Vapor retarders should be installed on the warm side, the lived-in side, of the space to be insulated. This placement prevents the moisture in the warm indoor air from reaching the insulation.

## How much should I use

After the three preliminary measures have been addressed, you can begin looking for areas that are deficient in insulation. The type and amount of material used affects how well the insulation works. Insulation material is rated according to its R-value, or resistance to heat flow. The higher the R-value the better the insulation is in reducing heat flow.

The ILDCO recommends the following "R" levels of insulation for this region. see revised table

Area	Recommended R-value
Attic	43
Wall (existing)	13
Wall (new)	21
Floor over unconditioned space	21
Basement wall	10
Crawl space wall	10

To determine if you need more insulation, you must first find out how much insulation you have. One way to do this is to check for yourself.

You will want to see if you have insulation (and how much) in the basement walls, exterior walls, floors above cold spaces, and ceilings below cold spaces. In unfinished areas such as attics, where structural frame elements are exposed, you can see the type of insulation and measure its thickness.

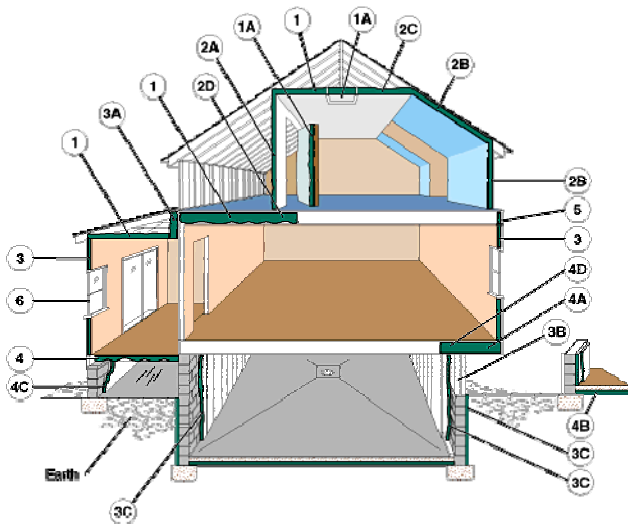
The table below shows typical R-values of insulation.

	Insulation Type					
	Roll or Batt	Blown-in			Boards	Foam
Material	Fiberglass	Fiberglass	Cellulose	Mineral wool	Rigid board	Sprayed
R-value per inch	3.2	3.2	3.4	3.1	4.0 to 7	4.5 to 6.5

Compare the existing levels with the ILDCO recommended levels. Now you are ready to begin.

## Where to insulate

The following diagram illustrates where insulation should be added. The simple rule of thumb to follow is to insulate components that are adjacent to the outside or intentionally unheated areas.



**1.** In unfinished attic spaces, insulate between and over the floor joists to seal off living spaces below.\*

**1A.** attic access door

**2.** In finished attic rooms with or without dormer, insulate:

**2A.** between the studs of "knee" walls;

**2B.** between the studs and rafters of exterior walls and roof;

**2C.** ceilings with cold spaces above;

**2D.** extend insulation into joist space to reduce air flows.

**3.** All exterior walls, including:

**3A.** walls between living spaces and unheated garages, shed roofs, or storage areas;

**3B.** walls above ground level; **3C** foundation walls in heated basements, full wall either interior or exterior.

**4.** Floors above cold spaces, such as vented crawl spaces and unheated garages. Also insulate:

**4A.** any portion of the floor in a room that is cantilevered beyond the exterior wall below;

**4B.** slab floors built directly on the ground;\*\*

**4C.** as an alternative to floor insulation, foundation walls of unvented crawl spaces;

**4D.** extend insulation into joist space to reduce air flows.

**5.** Band joists.

**6.** Replacement or storm windows and caulk and seal around all windows and doors.

Notes:

\*Well-insulated attics, crawl spaces, storage areas, and other enclosed cavities should be ventilated to prevent excess moisture build-up.

\*\*For new construction, slab on grade insulation should be installed to the extent required by building codes, or greater.

## What kind should I use

Once you have located the areas in your house requiring insulation, and have determined what R-value is needed, you will need to decide what type to buy. Some types of insulation require professional installation, and others you can install. You should consider the several forms of insulation available, their R-values, and the thickness needed. Remember, for a given type and weight of insulation, the thicker it is, the higher the R-value.

The type of insulation you use will be determined by the nature of the spaces in the house that you plan to insulate. For example, since you cannot conveniently "pour" insulation into an overhead space, blankets spray or board products, are used between the joists. The most economical way to fill closed cavities in finished walls is with blown-in insulation applied with pneumatic equipment or with foamed-in-place foam insulation.

It is important to know that the different forms of insulation can be used together. For example, you can add batt or roll insulation over loose-fill insulation, or vice-versa. Usually, material of higher density (weight per unit volume) should not be placed on top of lower density insulation that is easily compressed. Doing so will reduce the thickness of the material underneath and thereby lower its R-value. In cold climates, some low-density loose-fill insulation allows air to circulate between the top of your ceiling and the attic. This air circulation can decrease the effective thermal resistance of the insulation. You can eliminate this air circulation by covering the loose-fill insulation with a blanket insulation product or with a higher density loose-fill insulation.

## Basic forms of thermal insulation

**Blankets**, in the form of batts or rolls, are flexible products made from mineral fibers. They are available in widths suited to standard spacings of wall studs and attic or floor joists. Continuous rolls can be hand-cut and trimmed to fit.



They are available with or without vapor retarder facings. Batts with a special flame-resistant facing are available in various widths for basement walls where the insulation will be left exposed.

**Blown-in** loose-fill insulation includes loose fibers or fiber pellets that are blown into building cavities or attics using special pneumatic equipment. Another form includes fibers that are co-sprayed with an adhesive to make them resistant to settling. The blown-in material can provide additional resistance to air infiltration if the insulation is sufficiently dense.

**Foamed-in-place** foam insulation can be applied by a professional applicator using special equipment to meter, mix, and spray into place. Foam can also help to reduce air leaks.

**Rigid insulation** is made from fibrous materials or plastic foams and is pressed or extruded into board-like forms and molded pipe-coverings. These provide thermal and acoustical insulation, strength with low weight, and coverage with few heat loss paths. Such boards may be faced with a reflective foil that reduces heat flow when next to an air space.



**Reflective insulation systems** are fabricated from aluminum foils with a variety of backings such as kraft paper, plastic film, polyethylene bubbles, or cardboard. The resistance to heat flow depends on the heat flow direction, and this type of insulation is most effective in reducing downward heat flow. Reflective systems are typically located between roof rafters, floor joists, or wall studs. If a single reflective surface is used alone and faces an open space, such as an attic, it is called a **Radiant barrier**. Radiant barriers are installed in buildings to reduce summer heat gain and winter heat loss. All radiant barriers must have a low emittance (0.1 or less) and high reflectance (0.9 or more).

#### **Insulation Priorities**

- Provide the recommended level of insulation under floors above unheated spaces, around walls in a heated basement or unventilated crawl space, and on the edges of slabs-on-grade.

It is most important to:

- Insulate your attic to the recommended level, including the attic door, or hatch cover.

#### **Basement insulation**

Insulating the basement is relatively expensive, but it makes a significant difference in comfort and energy use and adds to the living space of the home. Two options for insulating the basement are presented; insulating from the outside and insulating from the inside. When considering insulating from the inside, you must make sure that the walls are perfectly dry. You may need to trench outside the wall to add a waterproofing membrane (if you need to do this, then consider adding exterior insulation) if you have cracks, or repair faulty gutters or downspouts. The concern with damp basement walls is that interior basement wall insulation could likely create conditions favorable to formation of mold and mildew. Waterproof paint, by itself, is not an effective remedy against moisture problems. After resolving outside sources of the problem, then waterproof paint can be applied before insulating and finishing the inside.

#### **Exterior insulation method**

The preferred method, from a building science perspective, is to insulate the wall on the outside with rigid insulation suitable for below-grade installations. The advantages are:

- Insulating the outside of the basement works well with dampproofing and foundation drainage. Insulation can act as a drainage layer, keeping surface and ground water away from the foundation.
- Basement walls are kept at room temperature protecting the structure, reducing the risk of interior condensation and increasing comfort. The disadvantages are the disturbance of landscaping, the need to cover the insulation above grade, and leaving an unfinished interior basement wall. Insulating the exterior will, in effect, tighten the basement walls and reduce the airflow.

#### **Interior insulation methods**

For dry interior basement walls, extruded polystyrene insulation with a wall side vapor retarder is a recommended insulation system. This is intended for an extruded foam plastic insulation (extruded polystyrene, or equivalent with a similar water vapor permeability) and is designed to keep the insulation protected from exterior moisture sources. The rigid insulation will serve as its own partial vapor retarder (allowing drying of any absorbed moisture to the inside).

#### **Do not forget the rim joist**

The rim joist is the wood member that wraps around the basement perimeter above the foundation wall. It is part of

the first floor, floor-framing system. This area is susceptible to thermal deficiencies since it is sometimes concealed above a dropped or plaster ceiling.

To insulate and to prevent moisture buildup in the rim joist cavity, it is recommended not to stuff the rim with fiberglass batt insulation. Instead, use foil-faced polyisocyanurate insulation. Seal the foil-faced insulation in place by caulking the edges.

### Exterior wall insulation

The insulation of exterior walls is an expensive measure that requires the services of a contractor. Costs range from 30 cents to \$1.65 per square foot (about \$1,500 for an average home), but savings could amount to 20 percent of heating and cooling costs. In some older homes, the exterior walls are not only uninsulated but the cavity between the inside and outside walls is often open to both the basement and the attic. As a result, a circulating column of air conducts heat from the basement, past the inner living space, up to the attic, and out of the house. One study showed that blowing high-density cellulose into the wall cavity of an old house could reduce air leakage by 50 percent.

If you own a wood sided home or a brick veneer home, insulation may be added in the wall stud cavity. It may be necessary to remove the interior drywall to install roll or batt insulation and may prove to be expensive. Nevertheless, if you plan to remodel, insulation may be blow-in from the inside and the holes will be patched as part of the remodeling. In homes that have wood siding, insulation may be blow-in from the outside. This is best done by a contractor who has a good knowledge of building construction and can foresee where obstructions may occur, such as fire stops in cavities. The contractor may use an infrared camera during the process to verify that the wall is completely insulated.

In some cases where the house is built using balloon framing, it may be possible to pour-in insulation from the attic. Balloon framing is a construction method that hangs the floors to the outside walls. This building technique creates shafts between the framing members that run from basement to attic.

In homes that have solid brick walls, the choices are limited and expensive. Insulating from the outside requires the



installation of furring strips to hold the insulation system in place. The insulation (usually rigid board) is secured to the furring strips and a coating is added to protect the insulation from the elements.

The second option for solid brick walls is to insulate from the inside. Since the walls usually have a 1" or 3/4" furring strips between the wall and wood lath, spray foam insulation may be injected into the cavity. This requires drilling through the interior wall finish. This option is not recommended if pulley-wells are used for your windows as the foam may fill these cavities making the windows inoperable.

It makes more sense to add the insulation over the plaster finish. Depending on what type of insulation you choose to use, you will lose a certain amount of living floor space. For instance, if you choose to use fiberglass batt insulation, you will need to install 3' of insulation to obtain an R-11 rating. This means that you will lose approximately 4' of floor space for each wall you insulate. If you choose to use rigid board insulation, you only need 1 1/2' for the R-11 rating and you may only lose about 2' for every wall insulated.

### Attic or Ceiling Insulation

Insulating an attic will cost between \$100 and \$1,000 depending on whether the attic already has some insulation or not. Annual heating savings should range from around 5 percent if insulation is being added to present insulation to as much as 30 percent if the attic had no insulation at all.

Placing insulation in the attic floor is usually easy, requiring only laying the material between the parallel joists of the frame. Be careful about where you step in the attic. Walk only on the joists so that you won't fall through the drywall ceiling. You may need to place walking boards across the tops of the joists to make the job easier. Remember that it is important to seal up air leaks between your living space and the attic before adding insulation in your attic. Also, bear in mind that insulation placed between joists, rafters, and studs does not retard heat flow through the exposed frame.

### Caution

Follow these safety precautions. Do not cover or hand-pack insulation around bare stovepipes, electrical fixtures, motors, or any heat-producing equipment such as recessed lighting fixtures. In addition, if your home is very old, you may want to have an electrician check to see if the electrical insulation on your wiring is degraded or if the wires are overloaded. In either of these two situations, it may be hazardous to add thermal insulation within a closed cavity

around the wires because that could cause the wires to overheat. If your home was wired using a now obsolete method called knob and tube wiring, the National Electric Code forbids the installation of loose, rolled, or foam-in-place insulation if the insulation would surround the wires and prevent heat dissipation from the electrical conductors to a free air space.

Do not cover attic vents with insulation. Proper ventilation, especially in attics, must be maintained to avoid overheating in summer and moisture build-up all year long.

### **Floors over unheated spaces**

Insulating floors over unheated spaces, such as garages and crawl spaces, could cost from \$200 to \$400. Savings could amount to 8 percent on previous heating and cooling costs.

As with attic or ceiling insulation, a choice of insulating materials varies. Roll or batt insulation may be adequate since loose fill insulation needs a closed cavity for ease of installation. Blown insulation may be used if the floor cavity is already enclosed.

If you insulate a floor above a crawl space, all ducts and water lines running below the insulation should be insulated as well. Insulate crawl space walls *only* if the crawl space is dry all year, the floor above is not insulated, all ventilation to the crawl space is blocked, and a vapor retarder (e.g., heavyweight polyethylene film) is installed on the ground to reduce moisture migration into the crawl space.

### **Special Reminders**

Never compress or fluff your insulation because it will change the R-value of the insulation. R-values are computed with the insulation in its "natural state". For example, fiberglass batts will expand after a batt is unrolled. Blown or poured cellulose will tend to settle over time. These events have been taken into account in computing their R-values.

For basement walls, a vapor barrier should be installed on the walls first, before the framing is installed. This common sense step that is often skipped in basement renovations, will considerably lessen the migration of moisture through the foundation walls.

Though fiberglass batts can be used successfully for basement walls, foam boards are also a good choice for insulation in basement renovations, since they have the advantage of not absorbing water in case of a water leak. Some of the major manufacturers make a foam board product specifically designed for basement applications.

If you use batt insulation with a reflective aluminum facing, you must allow some space (about an inch) between the facing and the wallboard. This air gap will significantly increase the amount of thermal energy reflected back to the home. To achieve this gap, staple the insulation to the inside of the stud instead of the edge. Don't compress the insulation excessively; a little air space is all that is needed.

When adding additional insulation to an attic that is already insulated, never use insulation with a vapor barrier. If you do, there is a chance that moisture that has slipped by the first vapor barrier will become trapped by the second vapor barrier, decreasing the value of your insulation.

Never jam insulation against the roofline of your attic. You know... into that tight place where the roof meets the attic floor. This can cause a cold spot on the roof in the winter months or a hot spot in the summer. The cold spot could lead to ice damming... and the hot spot could lead to overheating and possible damage to the roofing material.

If you have a ridge and soffit ventilation system, do not interfere with the flow of air by blocking the soffit vents. You can build little dams out of wood to hold the insulation back, or use a commercial product instead.

### **Bibliography**

- Minnesota Department of Commerce Energy Information Center, *Techniques, Tactics & Tips, Home Energy Guide to Home Insulation*. Energy Information Center publications are available free.
- City of Chicago, Department of the Environment
- Grateful acknowledgement is given by the Department of Commerce and Economic Opportunity to the City of Chicago for the use of this document.