COLORADO STATE UNIVERSITY
EXTENSION

Insulating Colorado Homes

Fact Sheet 10.635 Consumer Series | Energy

*By C. Weiner**

Quick Facts

Insulation keeps heat in the home during cold months and also keeps unwanted heat out during warm months.

A well insulated home is tightly sealed and has recommended levels of insulation around the exterior of all conditioned spaces (spaces where heating and/or cooling are provided).

It is critical to install insulation properly to achieve desired R-values.

It is possible to estimate a simple payback period for adding insulation to the home.

Well-insulated homes can be more comfortable to live in, have increased resale values, and have lower energy costs compared to poorly insulated homes. There are many options to choose from when considering adding insulation to a home and understanding some basic concepts about insulation can help you make the right decision for your situation. This fact sheet covers: how insulation works; how to determine existing levels of insulation; recommended levels of insulation for different spaces; different types of insulation; and financial and other considerations.

Insulation Basics

It is important to understand what insulation can and cannot do for a home. Insulation slows the ability of heat to move between two places—such as the warm inside of the house in winter towards the cold outside or between the conditioned space of your home and an unconditioned garage or crawlspace. Insulation both keeps wanted heat in your home during cold months and also keeps unwanted heat out during warm months. Most insulation, however, does not stop air from infiltrating into or out of your home through small cracks or gaps. Only spray foam insulation (or rigid foam boards properly sealed to a surface) is intended to both insulate and air seal, although densely packed loose fill insulation may also have some ability to slow air leaks.

For this reason, it is important to consider sealing air leaks in the home before adding insulation. Once insulation is added to a space it will be more difficult and costly to uncover and plug air leaks. Without air sealing first you may still experience discomfort from drafts. Because air can move well through even the tiniest of gaps, energy bills may not decrease as much as you expected if you insulate without air sealing. See the CSU Extension fact sheet on air sealing for more information. It is also important to both seal air leaks and to use a vapor barrier on insulation as appropriate to avoid condensation and moisture buildup in the insulation itself.

Likewise, it is good to consider adding insulation before purchasing a new heating or cooling system. Spending money on insulation may allow the purchase of a smaller, less expensive heating system and may keep enough summer heat out of the home that you could reconsider the need for an active cooling system altogether.

Determining Your Insulation Levels

To decide whether adding insulation makes sense, first determine the current levels of insulation throughout the home. The level of insulation is measured by the R-value of the insulation. 'R' stands for 'resistance'; in this case it means resistance to heat flow. The higher the R-values the more effective the insulation.

Different types of insulation have different R-values based on the different characteristics of the insulating material. Table 1 provides commonly accepted R-values for various types of insulation, although it should be noted that the R-value can vary based on how well the insulation is installed as well as other factors.

Once you identify the type of insulation you have in a certain location and measure the depth of that insulation in inches you can figure out the total R-value of that insulation. For example,

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if an attic has 10 inches of fiberglass batt insulation:

R-value per inch x Number of inches = Total R-value

3.2 x 10 = R-32

It is much easier to measure insulation in areas that are accessible, such as attics and crawlspaces, than generally inaccessible areas such as walls. There are two ways to measure insulation levels in exterior walls.

Table 1. Commonly accepted R-values for various types of insulation.

What You See	What It Probably Is	R Value per Inch
Loose pink, yellow, or white fibers	Loosefill fiberglass	2.5
Gray, newspaper-like fibers	Loosefill cellulose	3.7
Dense gray white, or speckled fibers	Mineral wool	3.1
Pink, yellow, or white blankets/rolls	Fiberglass batt	3.2
White rigid foam board	Expanded polystyrene board	4.0-4.5
Pink or blue rigid foam board/spray	Extruded polystyrene	5.0-5.5
Yellow or white rigid foam board/spray	Polyurethane board or spray	6.0-7.5

The first is to drill a small hole in the wall of a closet or behind an object such as a wall hanging or dresser (and not in a wall stud). Then use a pencil or similar non-conductive object to feel and/or pick away a small piece of insulation to identify the insulation type. If you don't know the depth of the studs (typically 4 or 6 inches), measure the wall cavity to determine the thickness of the insulation in inches.

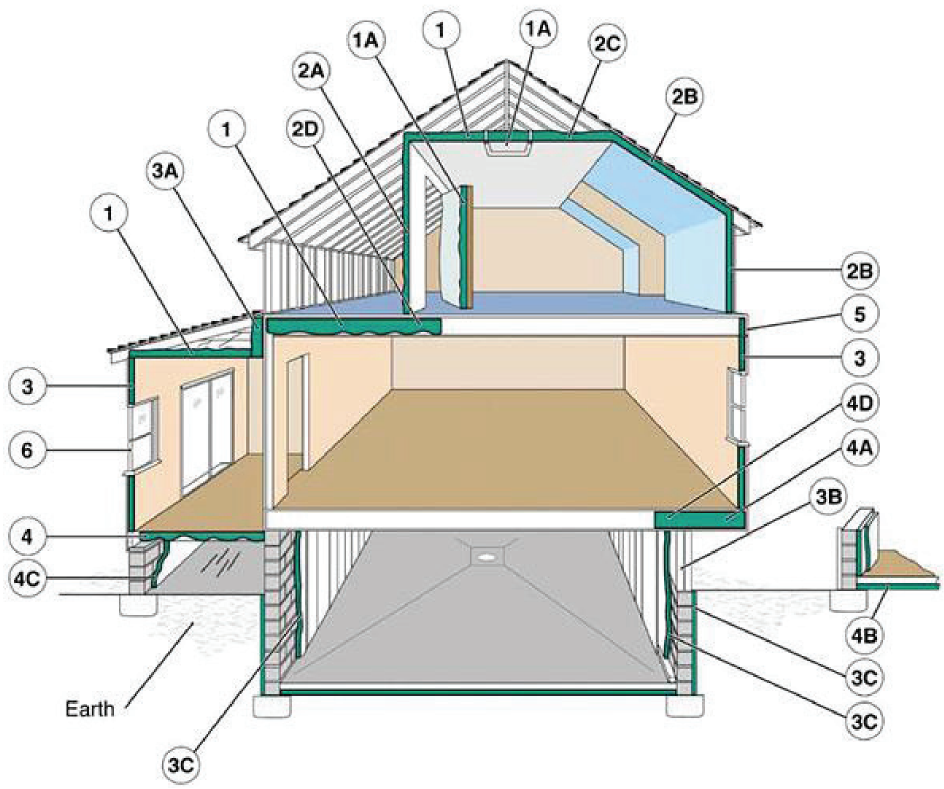
The second way to measure wall insulation involves first turning off the power to the home. Once the power is completely off, remove an outlet plate from an exterior wall. Then use a small, non-conductive, rigid object to pick away a small piece of insulation around the outlet box and to measure the depth of the wall cavity.

Keep in mind that different exterior walls may have different levels of insulation so it is best to check each wall separately. And although it is good to be aware of the R-value in exterior walls, insulating walls can be more difficult and costly than insulating other parts of your home. If you are planning to replace exterior siding, insulation can be blown in by cutting small holes from the outside of the home, blowing in the insulation, replacing the holes, and re-siding. Alternatively, an insulation contractor can cut small holes in the drywall from the inside, blow in the insulation, and patch, refinish, and paint the walls.

Insulating the Thermal Boundary

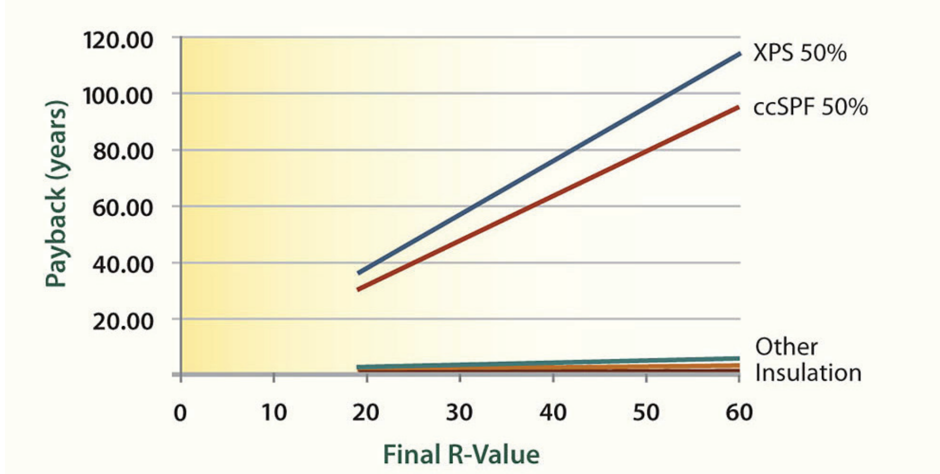
A well insulated home should be sealed and have insulation around the exterior of all conditioned spaces. The border between the sealed and insulated shell of a home and the outdoors or unconditioned spaces is referred to as the home's 'thermal boundary'. Different homes will have different thermal boundaries as illustrated in the image and caption below.

Because different parts of a home are interrelated, where to establish thermal boundaries depends on a number of factors. For example, the crawlspace ceiling (a.k.a. the home's floors) should be sealed and insulated in homes with ventilated crawlspaces, whereas the crawlspace walls should be sealed and insulated in homes with unventilated crawlspaces. Walls of both finished and unfinished basements should be sealed and insulated, since basements are more connected to other living spaces than to the outside. Special attention should be given to the rim joist area



Examples of where to insulate. 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) and 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) foundation 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. Source: Oak Ridge National Laboratory of the floor system that sits on the basement walls. Some municipalities require insulation in basement wall systems for both thermal comfort and fire protection. Be sure to check with your local building department about code requirements for insulation.

In addition to insulating the thermal boundaries of the home, be sure to also properly seal and insulate ductwork running through unconditioned spaces and to properly insulate pipes running through unconditioned spaces.



The greenhouse gas 'payback period' when using moderate to large amounts of certain foams can range from 30 to over 100 years. Source: www.buildinggreen.com

Adding Insulation

Once you've determined where the home's thermal boundaries are (or should be), and the R-value of existing insulation at these thermal boundaries, you can decide whether adding insulation is necessary. To make this decision, compare your current R-values with these recommended R-values for most Colorado homes:

Space	Recommended R-Value
Attic	49
Exterior Wall	18
Floor	25
Crawlspace	19
Basement	11

If the R-values in the spaces of the thermal boundary are significantly less than these recommended values, it should be cost-effective to add insulation to those spaces. Keep in mind that many in the insulation industry will recommend even higher R-values (i.e. R-60 in attics, R-30 in walls, and R-40 in floors). These recommendations are for homeowners interested in reducing energy use even further and/or for those living in cold mountain climates in the state. In any case, once you decide to add insulation the question then becomes: what type should I choose?

There are advantages and disadvantages to all types of insulation as shown in Table 2 which was adapted from the U.S. Department of Energy.

In general, batts or blankets are less expensive and can be installed by the homeowner. Blown-in insulation can also be installed by the homeowner and is highly versatile. Foams are more expensive but provide greater R-value per inch and can also provide an air seal. It should be noted, however, that greenhouse gas emissions associated with the blowing agent used to produce both extruded polystyrene foam board and standard closed cell spray polyurethane foam are so high that the 'greenhouse gas payback period' for installing these types of insulation can exceed 100 years if applied in large quantities.

One strategy to deal with this environmental imbalance as well as the high cost of these spray foams is to apply them in small amounts in conjunction with another type of insulation.

DIY vs. Contractor-Installed Insulation

If choosing to install insulation oneself, it is critical to install the insulation properly to achieve the stated R-values of the insulation. For example, if batts or blankets are compressed by wiring, plumbing, or outlet boxes they will lose R-value since the insulating air pockets in the material will be crushed. Other tips for DIY insulation projects include ensuring that the insulation is in complete contact with the surface to be insulated, that there are no gaps or spaces in the application of the insulation, that attic vents are not covered over or closed, that batts or blankets include only a single vapor barrier facing the inside of the home (do not add batts or blankets with vapor barriers on top of existing insulation), and that all fire safety measures (i.e. keeping insulation required distances from non-contact rated recessed can lights) are followed as specified in building code.

For those looking to hire a contractor to install blown-in insulation, achieving both the proper depth as well as the proper density is essential to ensure a quality job. Information an insulation contractor should provide following the installation includes: coverage area, initial installed thickness, minimum settled thickness, R-value, and the number of bags used.

Because blown-in insulation can be 'fluffed up' to appear to fill more height than it will when it settles, the number of bags used is critical. The number of bags used by the contractor can then be compared to the number of bags the manufacturer lists to achieve selected end R-value over a given area. Let's look at an example in which the manufacturer's chart on a bag of insulation indicates that 25 bags is the minimum required to achieve R-49 over 1,000 $ft.^2$. To calculate the number of bags required to achieve R-49 over an 1,800 $ft.^2$ area:

$$\frac{25 \text{ bags}}{1{,}000 \text{ ft.}^2} = 0.025 \text{ bags per ft.}^2$$

$$0.025 \text{ bags per ft.}^2 * 1{,}800 \text{ ft.}^2 = 45 \text{ bags required}$$

Table 2. Characteristics of common types of insulation.

Type	Insulation Materials	Common Application(s)	Advantages	Disadvantages
Blanket: batts and rolls	• Fiberglass • Mineral wool • Plastic fibers • Natural fibers	• Attics • Walls • Floors • Ceilings	• Do-it-yourself • Suited for standard stud and joist spacing that is relatively free from obstructions • Relatively inexpensive	• Prone to air gaps around edges • Compressing reduces R-value
Loose-fill and blown-in	• Cellulose • Fiberglass • Mineral wool	• Walls • Unfinished attics • Hard-to-reach areas	• Good for adding insulation to existing finished areas, irregularly shaped areas, and around obstructions • Can provide limited air sealing if densely packed	• Can settle over time and lose some of its overall R-value, especially if not packed densely • Imperative to measure based on number of bags used as opposed to number of inches because insulation can be “fluffed”
Sprayed foam and foamed-in-place	• Cementitious • Phenolic • Polyisocyanurate • Polyurethane	• Walls • Unfinished attics • Floors	• Good for adding insulation to existing finished areas, irregularly shaped areas, and around obstructions • Air seals as well as insulates	•High cost • The blowing agent for standard closed cell spray polyurethane foam is a potent greenhouse gas
Rigid foam board	• Polystyrene • Polyisocyanurate • Polyurethane	• Walls • Slabs • Cathedral ceilings • An insulated shething	• High insulating value for relatively little thickness • Can air seal as well as insulate when installed continuously over frames or joists and sealed together	• Not useful in round, jagged, or discontinuous areas • Flammable • Susceptible to termites • The blowing agent for extruded polystyrene foam is a potent greenhouse gas
Insulating concrete forms (ICFs)	• Foam boards or foam blocks	• Walls in new construction	• Insulation is literally built into the home’s walls, creating high thermal resistance	• For new construction only • More expensive than conventional wood frame construction • High embedded carbon footprint • Susceptible to air leaks where the ICFs meet wood
Structural insulated panels (SIPs)	• Foam board or liquid foam insulation core • Straw core insulation	• Walls, ceilings, floors, and roofs in new construction	• SIP-built houses provide superior and uniform insulation compared to more traditional construction methods and can be erected quickly where building season is short	• For new construction only • More expensive than conventional wood frame construction

Table 3. British Thermal Units (BTUs) per unit of fuel.

Fuel Source	BTU/Unit
Natural Gas	100,000 BTU/therm or 102,300 BTU/ccf
Propane	91,600 BTU/gal.
Electricity	3,412 BTU/kWh

Be sure to verify the number of bags used by the contractor on a receipt, and—even better—by asking the contractor to leave the opened, used bags for you to discard.

Estimating Payback Periods

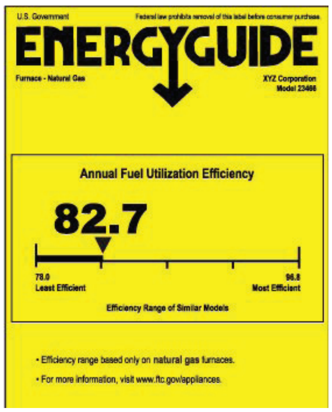
Before committing to additional insulation, most homeowners will want at least a sense of how quickly their investment will pay for itself. The time it takes for the financial savings from lower energy costs to equal the initial cost of installing the insulation is referred to as the simple payback period. While simple payback periods are flawed since they don’t usually account for changing energy prices and other factors, they remain the most common way to gauge an investment in energy efficiency. To calculate the simple payback period for adding insulation to a contiguous area, you must know the following:

- Installed cost per $ft.^2$ of insulation ($/ft.2)
- Cost of energy ($/BTU) - based on your fuel source (natural gas, propane, electricity, etc.)
- Efficiency of heating system—the Annual Fuel Utilization Efficiency (AFUE) for gas and propane systems or the Coefficient of Performance (COP) for electric systems

- Initial R-value of area to be insulated
- Final R-value of area to be insulated
- Heating degree days/year

Although it may seem difficult to obtain some of this information, there are some handy tips to get the information quickly. For cost of energy, you can glean your cost per therm, ccf, gallon, or kilowatt-hour from your energy bills. Once you have that, use Table 3 to convert that value into $/BTU.

The efficiency of gas-or propane-fired furnaces and boilers is often listed on the yellow Energy Guide label.



If AFUE is not listed, simply divide the output BTUs by the input BTUs as listed on the unit itself. Typical AFUE values are 0.6 to 0.88 for propane furnaces and 0.7 to 0.95 for natural gas furnaces. Use an efficiency value of 1.0 for baseboard electric systems, 2.1 to 2.5 for conventional heat pumps, and 3.2 to 3.5 for geothermal heat pumps.

Heating degree days/year can easily be obtained through an online search. A trusted site like the U.S. Department of Housing and Urban Development's database should be utilized. Heating degree days for select cities in Colorado are also listed:

City	HDD/Year
Alamosa	8,736
Burlington	6,261
Craig	8,351
Denver	6,128
Durango	6,779
Fort Collins	6,238
Grand Junction	5,489
Pueblo	5,598
Vail	10,646

Once you have collected all the necessary information, use the following equation to determine your simple payback period:

$$\text{Years to Payback} = \frac{(\text{Installed cost/ft.2} * \text{Initial R-value} * \text{Final R-value} * \text{Efficiency})}{(\text{Cost of energy} * \text{Difference between Initial and Final R-values} * \text{HDD} * 24)}$$

Note that this equation accounts only for savings from reduced heating costs; a reduction in cooling costs would be additional and would result in a quicker payback. Let's use the example of a 1,000 ft.2 attic in Denver, Colorado at R-27 that you want to insulate to R-49. Let's also assume you heat with natural gas at $0.70/therm ($0.000007/BTU) using an 83% efficient furnace. Your installer estimates a total cost of $0.25/ft.2 for the job.

$$\frac{(\$0.25/\text{ft.2} * 27 * 49 * 0.83)}{(0.000007 * 22 * 6{,}128 * 24)} = \frac{274.5}{22.6} = 12.1 \text{ years}$$

From the equation we can tell that low installed costs and low heating system efficiencies result in quicker payback periods. Similarly, high costs of energy and high numbers of heating degree days will result in quicker paybacks. Given energy prices over the last decade, homes heated by electricity have the shortest payback periods, followed by homes heated with propane. Homes heated with natural gas have had longer payback periods.

Of course, financial incentives can shorten payback periods. Federal tax credits and local utility companies often provide incentives for adding insulation. Be sure to ask your utility and contractor and/or check a website like www.dsireusa.org for up-to-date incentive information.

Other Considerations

In addition to posing challenges to occupant comfort and low energy bills, homes with cathedral or vaulted ceilings also pose challenges for both new and add-on insulation. In most cases, the spaces provided by the rafters of these ceilings are not large enough to accommodate recommended R-values for attic insulation (unless foam is used). Any retrofit to these ceilings would involve either expanding the existing ceiling inward through use of supplemental framing or adding rigid foam board insulation under the roof when replacing it.

The world of insulation is a constantly changing and evolving market of new products and materials. Denim, natural fibers, sheepwool, and even cork have entered the market with various advantages and disadvantages. It is important to investigate new insulation products thoroughly to understand how they may or may not be right for what your goals are for your home and budget.

Conclusions

Insulation slows the transfer of heat between two places and is therefore effective at reducing unwanted heat loss in cold months as well as reducing unwanted heat gain in warm months. The decision to add insulation to a home should be a result of identifying current R-values along the home's thermal boundaries and comparing those values to recommended R-values. Adding insulation should ideally be done after air sealing the home. Various types of insulation exist for different applications and preferences, and some types of foam insulation made with hydrofluorocarbon (HFC) blowing agents emit large amounts of greenhouse gas when produced.

Some types of insulation are easier to install than others, and both DIY and contractor installations require great care to be done properly. Be sure to investigate new insulating materials, financial incentives, and the specific details of your home before taking on an insulation project.

References

Environmental Building News (2010). Avoiding the Global Warming Impact of Insulation (Retrieved 5/31/13).
Green Building Advisor (2013). How to Build an Insulated Cathedral Ceiling (Retrieved 5/31/13).
Oak Ridge National Laboratory (2013). Insulation fact sheet (Retrieved 5/31/13).
U.S. Department of Energy (2013). Energysaver articles: Insulation (Retrieved 5/31/2013).
U.S. Department of Energy (2013). Guide to Home Insulation (Retrieved 5/31/13).
U.S. Department of Housing and Urban Development (2013). Heating Degree Day Database (Retrieved 5/30/13).