HOW YOUR HOUSE WORKS

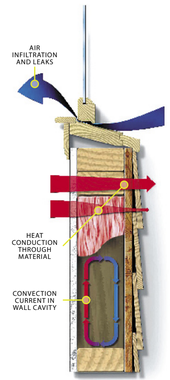
PART 4

INSULATION

BUILDERS NEVER aimed to construct drafty, leaky houses, but they really started tightening things up during the energy crunch of the 1970s. Then, as now, fuel costs drove improvements in insulation and the other parts of a house's "envelope," such as siding and windows. Mistakes were made. Urea-formaldehyde foam was eagerly retrofitted into homes, only to be pulled out later due to toxic outgassing. Zealous contractors draped rooms in plastic with little thought about healthy air and moisture buildup. Today, practices have improved. New spray foams that seal the house shell are challenging conventional methods, and in some regions sealed crawlspaces are gaining in popularity. Future advances promise to cut household bills in both winter and summer—and help the environment, too: The average American home generates as many fossil-fuel emissions as two cars.

ILLUSTRATIONS BY MICHAEL LLEWELYN

HOW HEAT MOVES



DRAFTS: In winter, cold air infiltrates around doors and windows, and through gaps in the walls. Warm air can escape through flues and around vents.

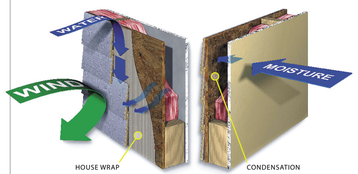
CONDUCTION: Heat moves through solid materials—quickly through good conductors such as metal, more slowly through wood, sluggishly through an insulator such as fiberglass batting.

CONVECTION: Air circulates within a house's walls, ferrying warmth to the outside wall (in winter) where conduction takes over. Convection can effectively boost heat loss by up to 25 percent.

RADIATION (NOT SHOWN): Heat also moves as infrared radiation. Reflective foil works as a radiant energy barrier.

BLOCKING WIND, CONTROLLING MOISTURE

Heat loss isn't the only challenge a house faces in winter. There's also moisture to contend with. The indoor environment is warm and humid compared to the outside, and this drives vapor into the walls where it can condense on cold surfaces. Builders install vapor barriers, usually paper facings on batts or plastic films, to control the problem. Special care must be taken around windows and other breaks to avoid excessive moisture that causes rot. To control drafts, house wrap goes on the outside. This material is waterproof, yet vapor-permeable so it won't lock moisture in the wall cavities.



WHAT'S IN A WALL?

Open up a modern home's exterior wall and you'll find the spaces between the studs filled with insulation that's been cut to fit, or blown, sprayed or poured in. Here's a quick overview.

FIBERGLASS BATTS, the most popular form of insulation, come precut or in rolls. Rock wool, a fireproof mineral-based material, also comes in batts.

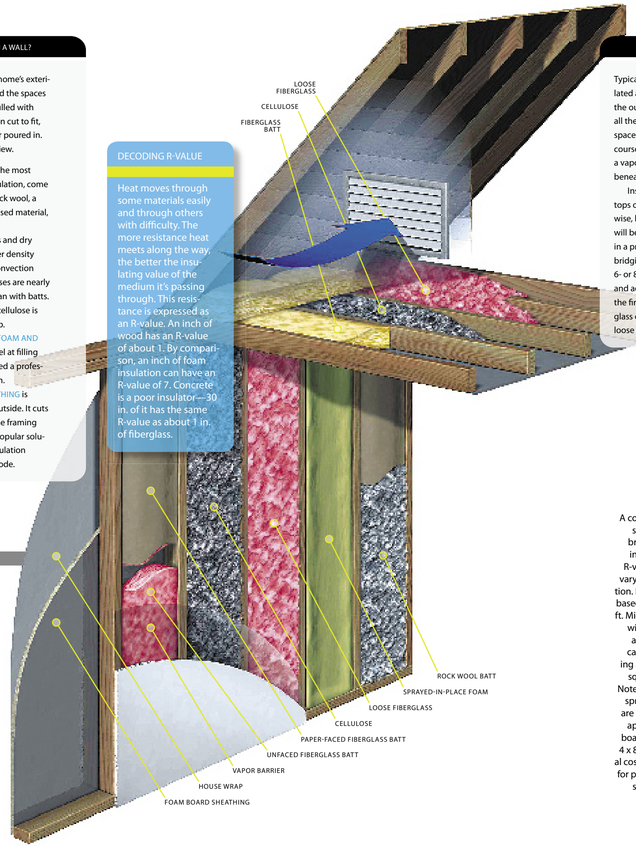
BLOWN-IN fiberglass and dry cellulose have higher density than batting, and convection and escaping air losses are nearly 70 percent lower than with batts. Installing blown-in cellulose is an accessible DIY job.

SPRAYED-IN-PLACE FOAM AND WET CELLULOSE excel at filling gaps—but you'll need a professional to install them.

FOAM BOARD SHEATHING is often used on the outside. It cuts heat loss through the framing members, and is a popular solution where extra insulation is needed to meet code.

DECODING R-VALUE

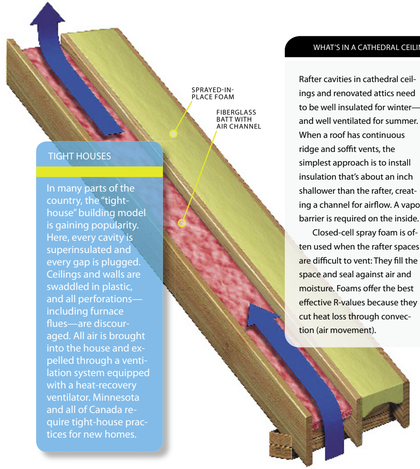
Heat moves through some materials easily and through others with difficulty. The more resistance heat meets along the way, the better the insulating value of the medium it's passing through. This resistance is expressed as an R-value. An inch of wood has an R-value of about 1. By comparison, an inch of foam insulation can have an R-value of 7. Concrete is a poor insulator—30 in. of it has the same R-value as about 1 in. of fiberglass.



WHAT'S IN AN ATTIC?

Typically, attic roofs are uninsulated and the space is vented to the outside. The idea is to keep all the heat down in the living space. The ceiling below is, of course, insulated. If there is a vapor barrier, it is placed beneath the insulation.

Insulation should cover the tops of the ceiling joists—otherwise, heat from the room below will be conducted into the attic in a process called thermal bridging. Some builders lay 6- or 8-in. batts between joists and add a second layer across the first. Others add loose fiberglass over batts, or use only loose fiberglass or cellulose.



TIGHT HOUSES

In many parts of the country, the "tight-house" building model is gaining popularity. Here, every cavity is superinsulated and every gap is plugged. Ceilings and walls are swaddled in plastic, and all perforations—including furnace flues—are discouraged. All air is brought into the house and expelled through a ventilation system equipped with a heat-recovery ventilator. Minnesota and all of Canada require tight-house practices for new homes.

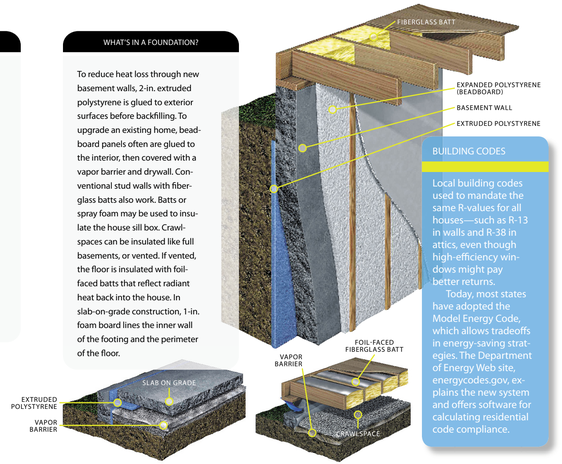
WHAT'S IN A CATHEDRAL CEILING?

Rafter cavities in cathedral ceilings and renovated attics need to be well insulated for winter—and well ventilated for summer. When a roof has continuous ridge and soffit vents, the simplest approach is to install insulation that's about an inch shallower than the rafter, creating a channel for airflow. A vapor barrier is required on the inside.

Closed-cell spray foam is often used when the rafter spaces are difficult to vent: They fill the space and seal against air and moisture. Foams offer the best effective R-values because they cut heat loss through convection (air movement).

WHAT'S IN A FOUNDATION?

To reduce heat loss through new basement walls, 2-in. extruded polystyrene is glued to exterior surfaces before backfilling. To upgrade an existing home, beadboard panels often are glued to the interior, then covered with a vapor barrier and drywall. Conventional stud walls with fiberglass batts also work. Batts or spray foam may be used to insulate the house sill box. Crawlspaces can be insulated like full basements, or vented. If vented, the floor is insulated with foil-faced batts that reflect radiant heat back into the house. In slab-on-grade construction, 1-in. foam board lines the inner wall of the footing and the perimeter of the floor.



BUILDING CODES

Local building codes used to mandate the same R-values for all houses—such as R-13 in walls and R-38 in attics, even though high-efficiency windows might pay better returns.

Today, most states have adopted the Model Energy Code, which allows tradeoffs in energy-saving strategies. The Department of Energy Web site, energycodes.gov, explains the new system and offers software for calculating residential code compliance.

THE WARM STUFF

A comparison of insulations reveals broad differences in both price and R-value. Prices also vary widely by location. Figures here are based on a 2000-sq.-ft. Midwestern home with a 2000-sq.-ft. attic, 3½-in. stud cavities, a flat ceiling and about 1700 sq. ft. of wall area. Notes: Polyurethane spray foam figures are based on a 2-in. application. Foam board prices are for 4 x 8 panels. Material costs are not given for professionally installed products.

FIBERGLASS

Fiberglass comes in 15- and 23-in.-wide batts and in several thicknesses, including 3½, 5½, 6 and 8 in. Various densities are available to meet different R-value requirements. R-11, R-13 and R-15 are all available in 3½-in. batts. Loose-fill fiberglass has an R-rating of about 2.5 per inch.

Fiberglass, batt
LOCATION: walls
R-VALUE: R-13
MATERIAL COST: $595
INSTALLED PRICE: $799

Fiberglass, blown
LOCATION: walls
R-VALUE: R-14
INSTALLED PRICE: $1870

Fiberglass, batt
LOCATION: attic
R-VALUE: R-30
MATERIAL COST: $1220
INSTALLED PRICE: $2140

Fiberglass, blown
LOCATION: attic
R-VALUE: R-30
MATERIAL COST: $720
INSTALLED PRICE: $1000

CELLULOSE

Cellulose is made from recycled paper products with boric acid added as a fire retardant and insect repellent. Dry cellulose has an R-rating of about 3.7 per inch. It usually costs less than fiberglass and has greater density, which helps fill voids. Blown-in wet cellulose seals better, but it needs 48 hours to dry.

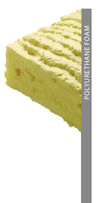
Cellulose, blown
LOCATION: attic
R-VALUE: R-30
MATERIAL COST: $700
INSTALLED PRICE: $1100

Cellulose, blown
LOCATION: walls
R-VALUE: R-14
MATERIAL COST: $425
INSTALLED PRICE: $1190

Cellulose, wet
LOCATION: walls
R-VALUE: R-14
INSTALLED PRICE: $1275

SPRAY FOAM

Closed-cell polyurethane foam offers high R-values—R-7 per inch—but it's expensive. It seals all gaps and doesn't require a vapor barrier. Lightweight, open-cell urethane is R-3.6 per inch and is also gap-sealing, but you'll need a vapor barrier.

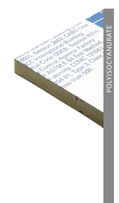


Closed-cell polyurethane spray foam
LOCATION: walls
R-VALUE: R-13
INSTALLED PRICE: $2210

Open-cell urethane spray foam
LOCATION: walls
R-VALUE: R-13
INSTALLED PRICE: $2380

FOAM BOARD

There are three types of rigid foam boards. The colored boards—pink, blue and green—are extruded polystyrene, while foil-faced boards are polyisocyanurate. White beadboard is expanded polystyrene and is used indoors. Foam boards vary between R-4 and R-7 per inch.



Expanded polystyrene
LOCATION: interior
R-VALUE, 1 IN.: R-4
4 X 8 PANEL COST: $9

Extruded polystyrene
LOCATION: foundations, sheathing
R-VALUE, 1 IN.: R-5
4 X 8 PANEL COST: $11

Polyisocyanurate
LOCATION: sheathing
R-VALUE, 1 IN.: R-7
4 X 8 PANEL COST: $15