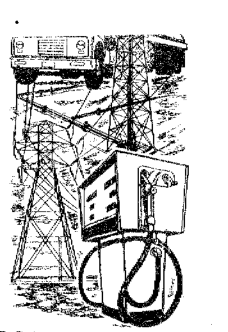

Save Home Heating Dollars

As the cost of energy rises, families are considering all possible ways to save on their home heating bills, since space heating is responsible for nearly three-fourths of the energy used in the home. When money is invested to reduce heating bills, families want to know how long it will take for savings to repay their investments. Which investment will result in the greatest savings—insulation of ceilings, walls, floors, storm windows, or storm doors? Choices may need to be made and priorities established if money is not available to do it all. In making the decision, it is important to understand how heat is lost from a home.

How heat is lost from a home

Our bodies continually produce heat through burning of food, and must continually lose this heat if we are to maintain the necessary constant body temperature. We must have a balance between heat production and heat loss. If we lose too much heat, we are uncomfortably chilly. Then we must either put on more clothing to reduce the rate of heat loss, exercise to increase production of heat, or raise the temperature around us. We may turn up the thermostat, stand near a heat register, or find a sunny window.

We lose body heat by several methods. If we touch cold objects, heat flows by conduction from the warmer object (body) to the colder objects. Bare feet on a cold floor is an example. Shoe soles or a rug on the floor provide some insulation between these objects, and reduce the conduction.

Warm bodies also lose heat to cool air. Heat always flows from warmer to cooler areas, causing convection currents of air between objects of varying temperatures (such as a warm body and a cold window glass). We also lose some heat to the cold glass by radiation from our skin. Radiation is the transfer of heat by electro-magnetic waves from a warm object to a colder object without heating the air in between. It is this kind of heat that we get from the sun's rays, and also from houses heated with electric wires embedded in the ceilings.

A house loses heat by the same methods that the human body loses heat: conduction, convection, and radiation, plus air moving into and out of the house (infiltration and exfiltration). "Insulation" is any material that slows down conductive heat flow, which in winter is from the inside of the house to the outside, and on a hot summer's day is from the outside to the inside. Every piece of material used in house construction has a different "R-value," which means "resistance to heat flow." Insulation occurs when air is trapped within a material. For example, that fluff of fiberglass insulation provides air pockets that reduce heat flow. The dead air space between two panes of glass provides the insulation in "double-glazed" windows or single-pane windows with storm windows added. Glass itself has very little insulation value.

Heat is added to a house by radiant heat from the sun, by body heat from the people within a house, and by heat from lights, appliances, and burning of fuels. In the winter, the heat from the sun that enters a house through the windows can be a useful supplement. The people in a house, sitting quietly, will each give off about 400 Btu's of heat per hour. A Btu (British thermal unit) is a measure of heat, defined as the amount of heat required to warm 1 pound of water 1 degree Fahrenheit. There are a given number of Btu's in a kilowatt hour of electricity, a therm of gas, or a gallon of heating oil.

The humidity of the air inside a house contributes to the comfort level of the occupants. A relative humidity of 50 percent will provide an adequate feeling of warmth at lower thermostat temperature settings. Humidifiers and dehumidifiers are available to regulate the humidity within a home.

Air infiltration and exfiltration through cracks around windows and doors is a significant source of heat loss. Caulking around the outside of window frames is important. Weatherstripping should be used on operable parts of windows and doors.

Windows and heat loss

It is a common assumption that drawing draperies and pulling down shades are effective methods of reducing heat loss through windows. Recent experiments have been conducted at the University of Georgia and the Illinois Institute of Technology which demonstrated the effect of

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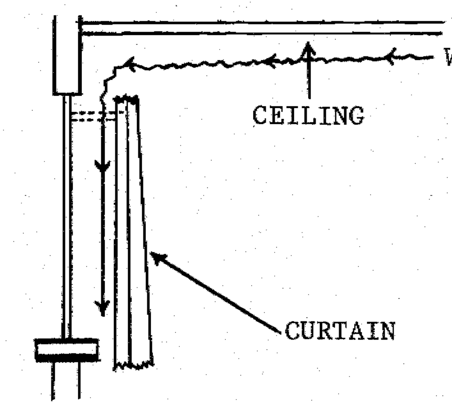
air flow behind window coverings (draperies or shades) that were hung in front of window frames. The results showed that the air flowed behind and became cooler and heavier when it contacted the window glass, then fell faster and pulled in more air from the top, creating a reverse chimney effect. The window coverings therefore did not reduce heat loss significantly. When a close-fitting cornice board was installed over the drapery in the Georgia experiment[1] and drapery edges were sealed, heat loss through the window was reduced 21 percent. When the top edge was unpinned from the cornice board, the highest reduction was slightly over 9 percent.



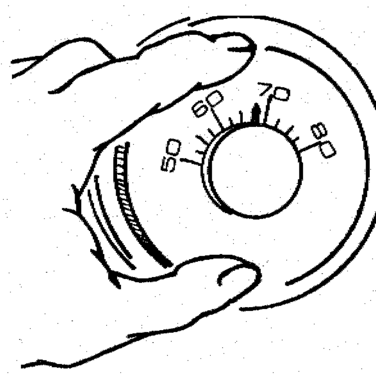
In the Illinois research,[2] a window shade installed within the window frame (with ¼" clearance on either side) resulted in a 28 percent reduction in heat loss through the window. This can be attributed to the placement of the shade inside the window frame close to the glass, which minimized the air flow between the shade and the glass. When a shade was hung outside of the window frame, heat loss was reduced by only 12 percent.

Window covering used over single-pane glass	24-hour reduction in heat loss
Sheer curtains	None
Cafe curtains	None
Draperies, open top & bottom	None
Draperies, closed edges	5%*
Roller shades, vinyl-coated:	
Outside hung	6%*
Inside hung, ¼" gap at edges	14%*
Roller shades, reflective & transparent:	
Inside hung, fully drawn, ¼" gap at edges	32-49%
Roman shades (Stacks in accordian pleats):	
Outside hung, snug to frame	14%*
Inside hung, ¼" gap at edges	14%*
Fitted insulated shutters	57%*
Double glazing	50%
Triple glazing	66%

* Window covered 12 hours overnight, assuming equal temperature outside.

Manufacturers of transparent plastic shade material coated with a metallic spray claim up to a 50 percent reduction of heat loss when the shade is hung inside the window frame. The metallic surface reflects radiant heat back into the room. The radiation varies with type of coating.

Psychologically, people feel warmer when drapery fabric or window shades cover dark windows at night. Physically, radiant heat loss is reduced by the barrier placed between the person and the colder glass. Insulated window shades and drapery linings will further reduce radiant heat loss. This will be translated into more savings on the heat bill if the greater feeling of comfort results in a lowering of the thermostat. For every degree the thermostat is lowered during the day and evening, a savings of 3 percent should be realized in heating costs. In cold climates, a higher percent of savings is possible.



Heat losses from air convection can only be cut by keeping the air from the cold glass, or by warming up the cold glass through the addition of storm windows. Tight-fitting solid shutters on either the inside or outside of the window can help reduce heat loss at night. In cold areas, shutters are being used that have a "sandwich filling" of foam insulation. Corrugated cardboard has some insulating properties, and an inexpensive way of achieving some heat savings is to use a tight-fitting cardboard inset in each window at night during the winter season.

In order to achieve the greatest savings, window glass should be insulated during the day as well as at night by means of storm windows. In cold areas, double-glazed or insulated glass windows should be supplemented with storm windows. The insulative value (R-value) of a storm window over single-pane glass is calculated to be the same as a double-glazed window (two panes of glass installed in the same frame). Plastic film or rigid plastic gives the same insulation as glass, since the air space is the insulator. The greatest amount of insulation is achieved with a 1-inch air space between the storm window glass (or plastic) and the window glass. Less than 1 inch of air space reduces the R-value somewhat, but increasing the space more than 1 inch does not increase the insulating value.

Outside storm windows must fit tightly to produce the dead air space needed for insulation. If the regular window already in the house is not snug, or has "weep holes" as do aluminum frames, then some moisture in the room air will enter the air space and condense on the storm window glass or plastic. This condensation can be prevented by putting three or four small holes, widely spaced, in the outside storm window frame. This small, dispersed air leakage will not reduce the insulating effect to any significant degree. Inside storm windows should be tightly fitted with weatherstripping to prevent air leakage and moisture condensation problems.

[1] Research Bulletin 68, "Thermal Properties of Carpets and Draperies," University of Georgia College of Agriculture Experiment Station, Nov., 1969.

[2] "Window Shades and Energy Conservation," a study conducted by the Illinois Institute of Technology under a grant by the Window Shade Manufacturers Association, Dec., 1974.

Storm windows may have frames of wood, metal, or rigid vinyl. The window itself can be glass, rigid plastic, or one of the plastic films. Be sure to inquire about the effect of sunlight on the various kinds of films. Tear-strength is another characteristic to consider, especially for outside use. The thickness of films, expressed in "mils," (thousandth of an inch), does not affect the insulating value because the dead air space is the insulator. A 3-mil polyester film, for instance, is as good an insulator as a much thicker polyester film and is much less expensive. Because polyester film is very strong, the thin film will also resist tearing. Clarity and lack of visual distortion are also important considerations.

Walls, ceilings, and floors

Various types of insulation can be used in walls, ceilings, and floors. The R-value of the material determines how much heat flow is reduced. A larger R-value number indicates more insulating ability. Insulation can often be added to a ceiling area by the home owner, so the cost may be only that of the materials. If labor is a cost, this must be added to the investment figure. Walls in an existing house usually must be insulated by a commercial applicator, so the cost is higher than for insulating ceilings and floors, where the home owner can do the labor. The vapor barrier that must be put on the inside surface of the insulated wall is an additional cost. For these reasons, walls may represent the longest pay-back period for the investment of any of the areas where heat loss can be reduced.

Many people do not realize that considerable heat loss occurs through the floor, although it is obvious that floors covered with linoleum or vinyl are cold to the touch in winter. A rug, carpet or thickly-cushioned vinyl adds greatly to the comfort underfoot, and may reduce heat loss by 4 to 10 percent. As with draperies across cold windows, a rug or carpet will cut down on the amount of radiant heat loss from a person to the floor, and this may permit a lowering of the thermostat that will be reflected in heat bill savings. Adding 6 inches (R-19) of fiberglass insulation under the floor is very effective in reducing heating costs.

Information on the selection of insulation materials and vapor barriers for walls (when insulation is added to existing houses) is available in OSU Extension Circular 931, "Home Insulation," from your county Extension office.

Calculation Chart for your Home

The last part of this circular provides a simplified formula for a home owner to use in determining which investment in insulation and storm windows will pay off the best. The chart that follows can be filled in by using the formula and by calling stores that sell home improvement products.

Windows (When adding shades or other coverings, use percentage on "Window Coverings" table to figure savings)

Yearly heat loss cost as windows are now .... ________
Yearly heat loss cost when ________ is added ...... ________
Yearly savings
(subtract second line from first line) .... ________
Cost of window treatment* .... ________
Years to recapture initial investment
(divide cost by yearly savings) .... ________

Ceiling

Yearly heat loss cost as ceiling is now .... ________
Yearly heat loss cost when ________ is added ...... ________
Yearly savings
(subtract second line from first line) .... ________
Cost of insulation* .... ________
Years to recapture investment
(divide by yearly savings) .... ________

Walls

Yearly heat loss cost as walls are now .... ________
Yearly heat loss cost when ________ is added ...... ________
Yearly savings
(subtract second line from first line) .... ________
Cost of insulation and added vapor barrier* .... ________
Years to recapture investment
(divide by yearly savings) .... ________

Floor

Yearly heat loss cost as floor is now .... ________
Yearly heat loss cost when ________ is added ...... ________
Yearly savings
(subtract second line from first line) .... ________
Cost of insulation* .... ________
Years to recapture investment
(divide by yearly savings) .... ________

* If interest on investment is figured each year, the years to recapture the investment will be increased. Money invested in insulation cannot be put in a savings account at interest, so this "interest foregone" should be subtracted from the yearly savings.

How to Calculate Heat Bill Savings

Approximate heat bill savings data resulting from any of the above-listed retrofitting practices can be calculated by using the following master formula and appropriate figures from charts. Such data will be useful for determining which investment will pay off most quickly.

$$\frac{\text{Area} \times \text{U-Factor} \times \text{DD} \times \text{C} \times \text{cents/KWH}}{341{,}300} = \$/\text{yr}$$

Explanation of Formula Elements And Their Source

- **Area** (in square feet) of window, wall, ceiling, or floor.
- **U-Factor** (from chart) is number of Btu's of energy loss per hour per square foot of area per degree F. temperature difference between inside and outside surfaces.
- **DD** (from table) is degree-days per year for your locality.
- **C** is a universally-accepted constant that converts degree-days to degree hours plus allowing for other miscellaneous factors as infiltration losses, living habits, room sizes, etc.
- **cents/KWH** is local cost of electric energy for home heating.

  NOTE: The formula, as presented, is set up for calculating electric energy (KWH). If you use gas or oil as a fuel, refer to the "comparison" chart that follows, select the column that lists your present or projected gas or oil cost, then use the KWH rate at top of that column and insert it as the "cents/KWH" in formula.
- **341,300** is product of 3,413 (Btus per KWH) and 100 (to convert cents to dollars).
- **$/yr** is cost of energy to pay for the heat lost per year through the area of building component being calculated.

Use this formula (with the appropriate C value and U-factor) first to figure the heat cost before adding insulation or storm windows. Then use the formula again with the new U-factor and C-value that results from the added insulation or storm windows. The difference in the costs of heating is the approximate savings that will be realized when storm windows or insulation is added.

Divide the cost of the windows or insulation by the savings (subtract interest on investment) to determine how many years it will take to pay off the money spent for the windows or insulation. Remember that the costs of heating fuels will go up in years to come, so use the formula with higher fuel costs than those prevalent today.

Calculation Factors

U-Factor

	U-Factor
Single window	1.123
Single window with storm window	.56
Double glazed or insulating window	.56
Double window with storm window	.36
2 x 4 stud wall, uninsulated	.23
2 x 4 stud wall, R-7 insulation	.088
2 x 6 stud wall, R-19 insulation	.043
2 x 4 stud wall, R-11 insulation	.07
Ceiling, no insulation	.385
Ceiling, R-11 insulation	.074
Ceiling, R-19 insulation	.046
Ceiling, R-30 insulation	.031
Ceiling, R-38 insulation	.024
Floor, vinyl covering, no insulation	.277
Floor, vinyl covering, R-11 insulation	.068
Floor, vinyl covering, R-19 insulation	.044
Floor, carpet/rubber pad, no insulation	.206
Floor, carpet/rubber pad, R-11 insulation	.063
Floor, carpet/rubber pad, R-19 insulation	.042
Floor, carpet/rubber pad, R-30 insulation	.028

Degree days

"Degree days heating" is an expression of the year's accumulation of days x (65°F minus the mean daily outside temperature). For instance, if the mean temperature for a 24-hour period was 40°F there would be 25 degree days for that one day. Mean temperature is computed by adding the maximum and the minimum and dividing by two. This is a list of degree days in Oregon:

Arlington—4821	Elgin—6685	McMinnville—4970
Ashland—5089	Enterprise—7949	Medford—4930
Astoria—5295	Eugene—4739	Newport—5235
Baker—6906	Forest Grove—4851	North Bend—4688
Bandon—4509	Grants Pass—4975	Pendleton—5240
Bend—7117	Heppner—5744	Portland—4792
Brookings—4281	Hermiston—5123	Prineville—6753
Burns—7212	Hillsboro—4949	Redmond—6411
Clatskanie—5233	Hood River—5535	Reedsport—4579
Condon—6643	Klamath Falls—6516	Roseburg—4885
Corvallis—4854	La Grande—6069	Salem—4852
Cottage Grove—4890	Lakeview—7069	Seaside—4864
Dallas—5064	Madras—6441	Tillamook—5338
Durfur—5832	Malheur Exp. Sta.—5811	

C-Value

Find the line which describes the insulation and window situation of the house. The C-value on the last column is the number to be used in the master formula.

Glass	Insulation: Ceiling	Wall	Floor*	Approximate C-Value
Single	0	0	0	17
Single	R-7	0	0	15
Double	R-11	0	0	14
Single	R-13	0	0	14
Single	R-30	0	0	14
Single	R-13	R-7	0	14
Double	R-13	R-11	0	13
Single	R-19	R-11	0	13
Double	R-30	0	0	13
Single	R-19	R-11	R-9	13
Single	R-30	R-11	R-11	12
Double	R-19	R-11	R-9	12
Double	R-30	0	R-19	12
Double	R-30	R-11	R-19	10
Double	R-38	R-19	R-30	8

* In a two story home consider only floor over unheated space or on concrete slab (as in basement).

Cents/KWH

If heating with gas or oil, pick the price of electricity that is comparable with the gas or oil price you will pay, then use the electricity price in the master formula.

Types of fuel	Comparable costs of fuel					
Electricity/KWH	1.5¢	1.7¢	2¢	2.5¢	3.5¢	5.0¢
#2 Fuel oil/gallon[1]	44¢	50¢	59¢	74¢	$1.00	$1.48
LP Gas/gallon[1]	29¢	32¢	38¢	47¢	66¢	94¢
Gas (therm-100,000 Btu's)[1]	31¢	35¢	41¢	51¢	72¢	$1.02

[1] Figured for 70 percent furnace efficiency.