Heat loss and found
Insulation and heat loss in American homes

By **DR. JAY McGREW,** President Applied Science & Engineering

□ As THE PRICE of natural gas and other fossil fuels has soared, federal, state and local government officials, along with the public utilities, have cheered on Americans in a race to insulate and reinsulate their homes. The homeowner has been promised two rewards: a slashing of his heating bill and the pride of being part of a national effort to conserve energy.

But a recent study of home heating dynamics indicates the current faith in insulation may be based on erroneous assumptions, and that homeowners pouring money into the burgeoning insulation industry won't see the savings they have been promised.

After studying the data accumulated from extensive in-home measurements, Dr. Jay McGrew, of Applied Science and Engineering, concluded that the push of insulation was "an absolute consumer ripoff."

Dr. McGrew said the ripoff may not be intentional — that insulation vendors probably believe it is *the* answer to energy conservation. But his studies found that heat loss through uninsulated walls and ceilings fell far short of the insulation industry's estimates which vary from 35 to 60 per cent. The combined heat loss through uninsulated walls and ceilings in the houses studied averaged about 28 per cent.

Energy conservation in the home is a new concern, something that was ignored by most until rising prices forced it into their attention. The solution seemed obvious and simple — insulation of attic and walls. But a closer look at the heating dynamics of a house reveals that it is much more complex: that there isn't one, but many, parts to the solution: and that insulation doesn't constitute the largest part.

The Study

Between March and June of 1977, Applied Science and Engineering, an independent research group, undertook what is believed to be the most thorough study of its type. The group went into 31 Denver-area homes with sophisticated monitoring equipment to find out precisely what happens to energy consumption within the home.

These are some of their findings:

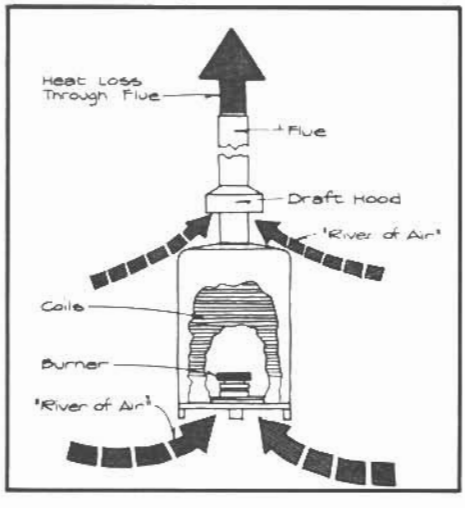
— The insulation in the homes varied from one to 10 inches in thickness. But the more heavily insulated homes consumed as much energy as the lightly insulated ones. There was absolutely no trend to substantiate measurable energy savings by increasing ceiling insulation beyond a relatively small thickness.

— The majority of the heat that is lost escapes through holes that are built into the home — through vents and chimneys. The average house has 95 square inches of vents and flues which work in a process called infiltration to create huge rivers of air which carry warm air out of the house and cold air in.

— Hot water tanks consumed a surprising amount of energy. In some houses the heating of water consumed more than half the natural gas. The average consumption was about 31 per cent of the total gas.

— Furnaces are notoriously wasteful, with most making use of less than 50 per cent of the heat created. That is, more than half of the heat produced goes straight up the chimney.

The study found that in a house with three inches of attic insulation, about 66 per cent of the heat is lost through infiltration, a process not affected by insulation. About 17 per cent of the heat is lost through windows, about 11 per cent through the ceiling, and about 6 per cent through uninsulated walls. It was found that the basic wall, with its air space between the siding and dryboard, is quite thermal effective and that adding insulation to it can only trim heat loss by one or two per cent.



The breakdown for heat escape in an uninsulated house was found to be: 57 per cent through infiltration, 23 per cent through the ceiling, 15 per cent through the windows, and five per cent through the walls.

Rivers of Air

The researchers used a precision hot-wire anemometer to measure the flow of air near the furnace, hot water heater, and kitchen and bathroom vents.

As the furnace is burning, room air is drawn into it far in excess of what is needed for combustion. The air is heated and sent gushing up the chimney. As air near the furnace is sucked in, air from elsewhere in the room flows to replace it. The researchers were able to measure a river of air pouring into the furnace at the rate of several hundred cubic feet a minute.

Because a house can't exist as a vacuum, every cubic inch of air that leaves the house must be replaced by new air coming in. So as warm house air is exhausted from one set of flues and vents, cold air from the outside is flowing in through the other. A wind can accelerate greatly this expensive exchange.

With a digital thermocouple, the researchers found that the hot water tank was sending air up its flue at a temperature of 136 degrees Fahrenheit while the flame was off, and 512 degrees Fahrenheit when it was on. Like the furnace, the hot water tank drew a constant river of air out of the house.

Room temperature air was drawn to the base of the tank, increasingly heated as it was pulled up through the tank, and exhausted through the standard three-inch flue.

This flow of air is bad on two counts. Warm air is being traded for cold. And the flow inhibits the efficiency of the water heater and furnace. The comparatively cold air constantly flowing from the room through the water heater has a cooling effect, requiring more flame time to maintain water temperature.

A furnace works through a heat exchanger, which is basically a pipe that

picks up the heat of the flame and transfers the heat to the water or air that is forced through it. The river of air the furnace constantly is sucking in robs the exchanger of heat as the air rushes past and up the chimney.

What You Can Do

If you don't have insulation in your attic, you should. The houses in the study lost about 23 per cent of their heat through uninsulated ceilings. But remember that three inches of insulation can cut this 23 per cent loss to 11 per cent. By doubling the thickness to six inches you can take that down by another 1 or 2 per cent, but anything beyond six inches is unnecessary overkill with little measurable effect.

The key fact is this: insulation is a good material and six inches can do the job nearly as well as 16 inches.

If you are building a house, three inches of wall insulation will be helpful. But if you are considering insulating the walls of an existing home, remember that the total heat loss through an uninsulated wall is only about five per cent. The addition of insulation will only trim this figure by one or two per cent, meaning the annual savings on a $400 heating bill would be less than $10. It is highly unlikely you would ever regain the cost of such a project.

When searching for ways to cut gas consumption, the hot water tank is a good place to start. A furnace is used only during the coldest six or seven months of the year, and usually it is turned down at night. But a water heater keeps a big pot of water — 40 gallons in most homes — very hot 24 hours a day, 365 days a year.

The study found that it increased the heater's gas consumption by 60 per cent to raise the temperature of tap water from 130 to 140 degrees Fahrenheit. Some tanks were kept at 150 and 160 degrees. The temperature could be cut easily to 120 degrees by just turning the temperature control knob most tanks have from "hot" toward "warm."

Some consumers believe it best to keep the water very hot because they use less of it. It is true that you will pass less water through the water heater this way, but the price of keeping the water at the elevated temperature — 24 hours a day — makes it a much more expensive thing to do.

Data from the study shows that you can save more money by turning your water heater from hot to warm than you can from reinsulating your attic from three inches to 13.

Further savings can be made by reducing the size of the tank from 40 to 30 gallons.

What Is Needed

Something that demands development is an automated damper valve that can close the flue when the flame of the water heater or furnace is off. This would do a lot toward harnessing the rivers of air that create the infiltration responsible for about two-thirds of a home's heating loss. Infiltration also works through cracks in caulking and worn weather stripping, but it takes a lot of cracks to equal one six-inch kitchen vent.

Furnaces being built today essentially are the same ones that have been built for years. They were designed in an era of cheap gas, when fuel efficiency wasn't an important matter. Far too much air is used in the combustion of the gas. The flow of air is unregulated. It is like running a car without a carburetor. The heat exchangers easily could be given more surface area so more of the combustion's heat would be utilized before it flows up the chimney.

For years we have had the technology to mass produce more efficient furnaces. As gas becomes more expensive, this technology certainly will be put to use.

Just as the rising price of gasoline unveiled the ability to design less thirsty cars, the rising price of natural gas will show that furnaces can be built that don't send 50 to 70 per cent of their heat ineffectively up the chimney. ▭