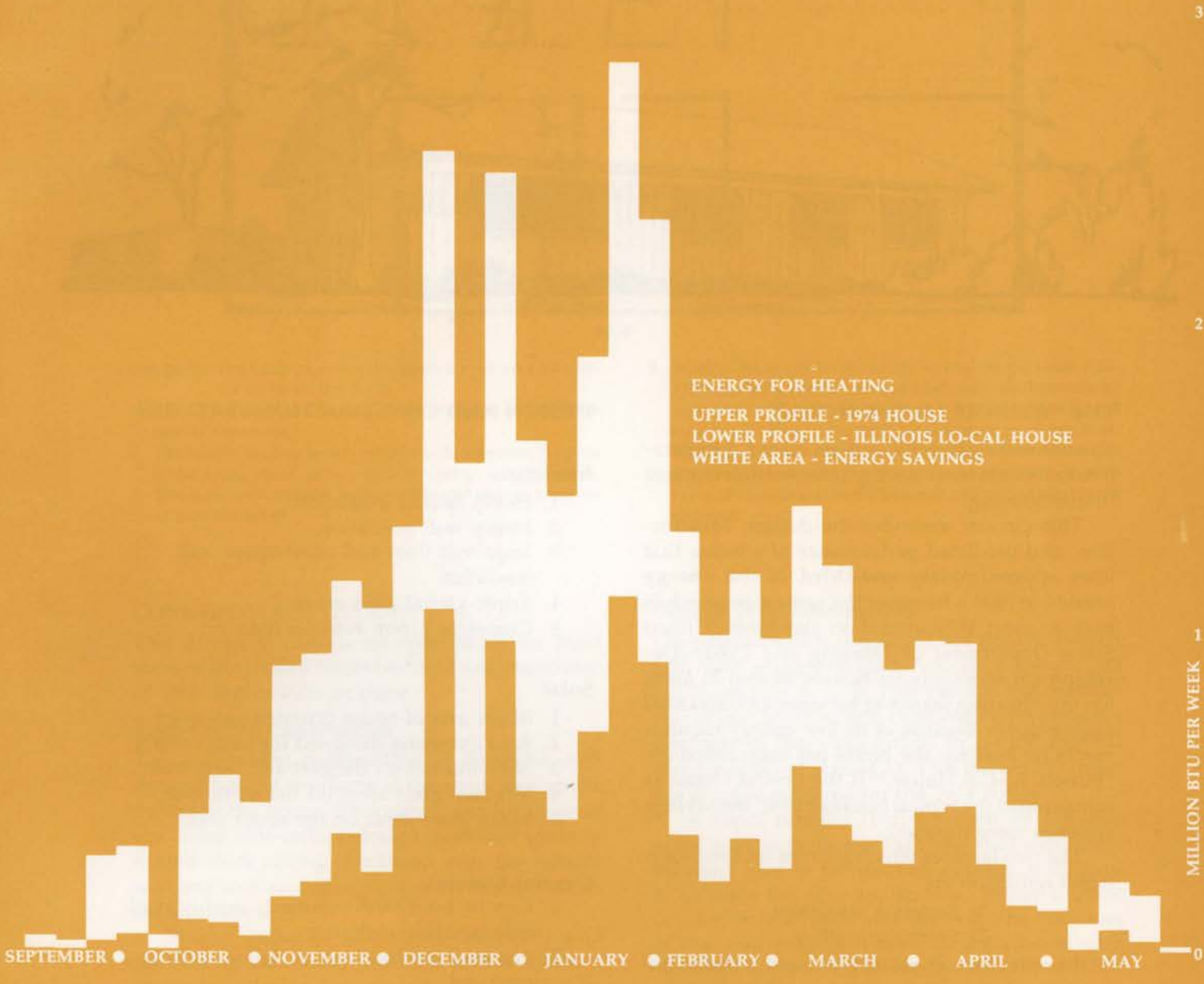
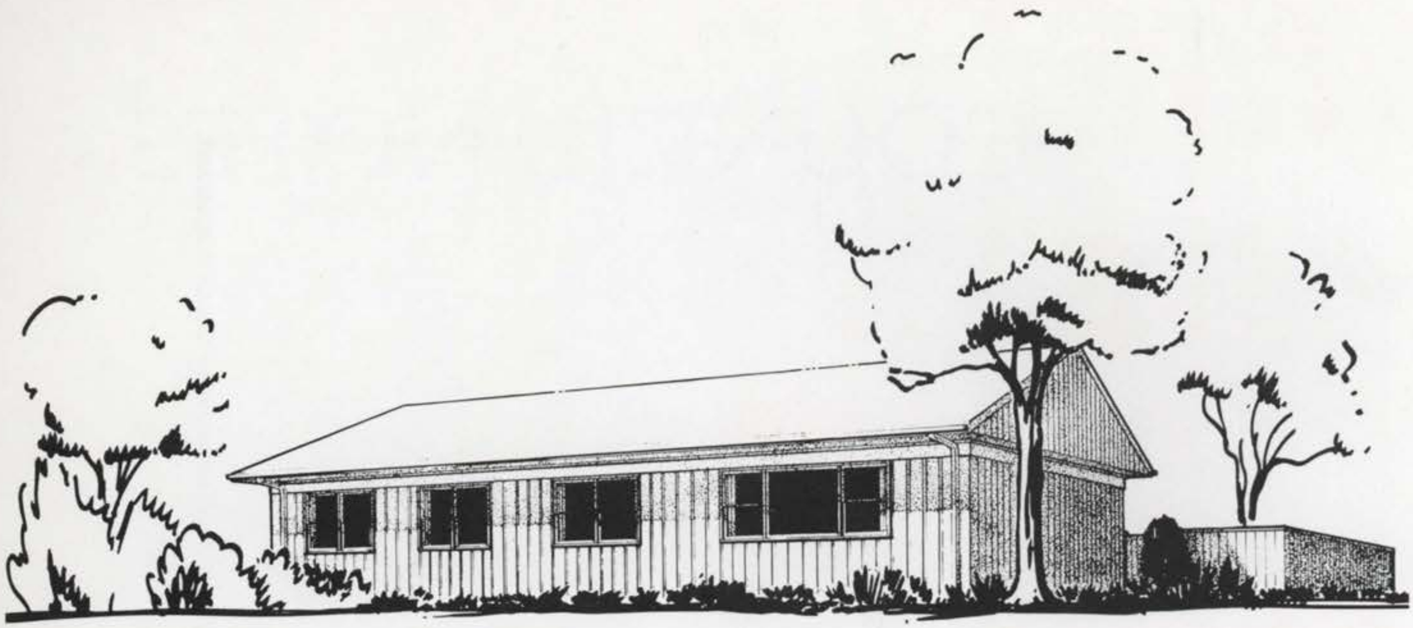
University of Illinois at Urbana-Champaign
Small Homes Council-Building Research Council

COUNCIL NOTES



C2.3 ILLINOIS LO-CAL HOUSE

Lo-Cal House C2.3 Volume 1 Number 4 Spring, 1976 Twenty five cents



THE "ILLINOIS LO-CAL HOUSE"

The increasing scarcity of fuels makes it imperative to include more energy conservation features in our housing.

This circular describes the design, construction, and predicted performance of a house that uses approximately **one-third** of the energy needed to heat a house of the same size which is built to meet 1974 insulation standards (United States Department of Housing and Urban Development standards for houses located in areas having a heating season of between 4500 and 8000 degree-days). Because of its low-energy requirements for heating, the house has been called the "Illinois Lo-Cal House." If the Lo-Cal House is compared to the typical house of 1950, the savings are even more dramatic.

The two features which account for the exceptional reduction are:

1) Superior insulation
2) Solar orientation

Of the reduction, about 80% or more is due to the heavy insulation. The remaining reduction is due to the location of most of the windows in the south wall, where they act as solar collectors.

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DESIGN AND CONSTRUCTION FEATURES

Insulation

1. Heavy ceiling insulation
2. Heavy wall insulation
3. Improved floor and crawl-space wall insulation
4. Triple-glazed glass areas
5. Complete vapor retarder (barrier)

Solar

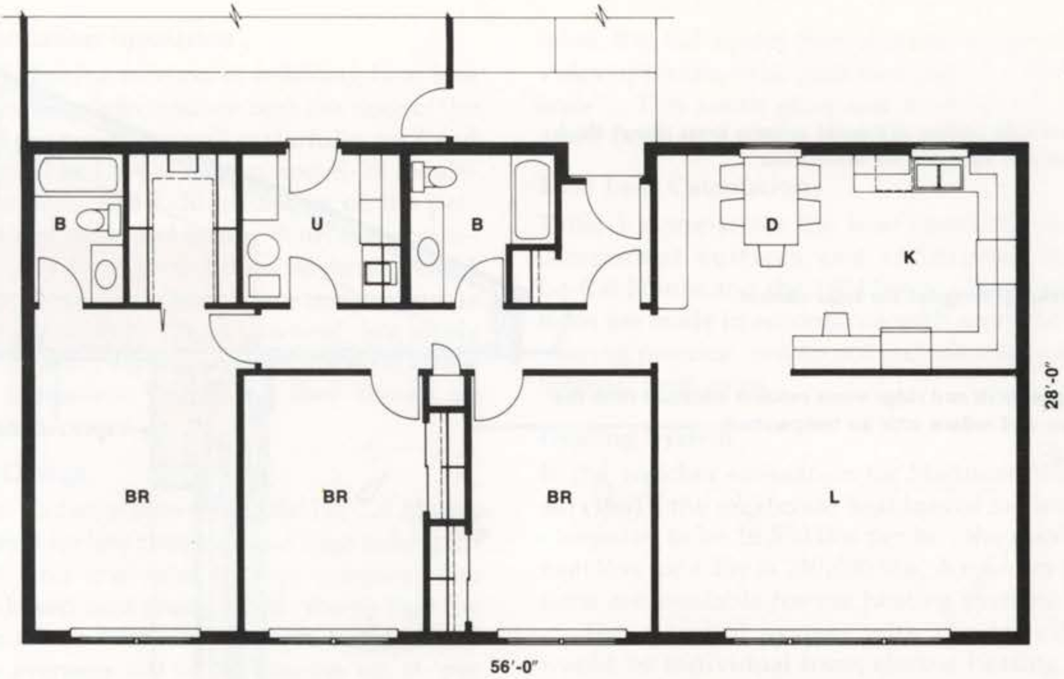
1. Major axis of house oriented east-west
2. Roof overhang designed for solar control
3. No windows on the east and west walls
4. Minimal glass areas on the north wall
5. Major glass areas on the south wall

General Features

1. Can be built with standard, readily available building materials
2. No new technology or labor skills are required
3. Design conforms to current practice
4. Design adapts to various lot orientations

Benefits

1. Low-cost heating system
2. Low-energy cost for heating
3. Low-cost cooling system
4. Low-energy cost for cooling
5. Favorable ratios of benefit to cost
6. Improved acoustic performance



Design A. The basic plan was designed for use on a lot with the street on the north.

1. **The living room and bedrooms are arranged on the south side of the house.**
2. **The family-kitchen area is on the north; however, it opens to the living room, from which it receives solar benefits.**
3. **The entrance vestibule, baths, utility and storage areas are also on the north.**
4. **Most of the windows (85%) are located on the south wall. The remaining windows are to meet code requirements for light and ventilation. There are no windows in the east and west walls. This is the best arrangement for thermal efficiency of the house. East and west windows should be used only when view is a prevailing requirement. In such cases, the windows should be small and well shaded in the summer.**

CONSTRUCTION DETAILS*

This design is considered appropriate for most areas of the United States having a heating season of 4500 degree-days or more.

Roof-Ceiling Construction

The roof-ceiling construction is designed with the soffit of the overhang at the same level as the ceiling of the house. This simple modification of the usual roof-ceiling design provides space to extend thick ceiling insulation over the outside wall and to maintain adequate ventilation above the insulation.

Twelve inches of insulation, combined with the ceiling structure, provides a total thermal resistance (R) of 38.5 compared to an R of 19.5 for the 1974 house.

A complete vapor retarder (barrier) is located immediately below the ceiling insulation. This may be a 6-mil polyethylene film or an aluminum foil on the back of the ceiling finish material.

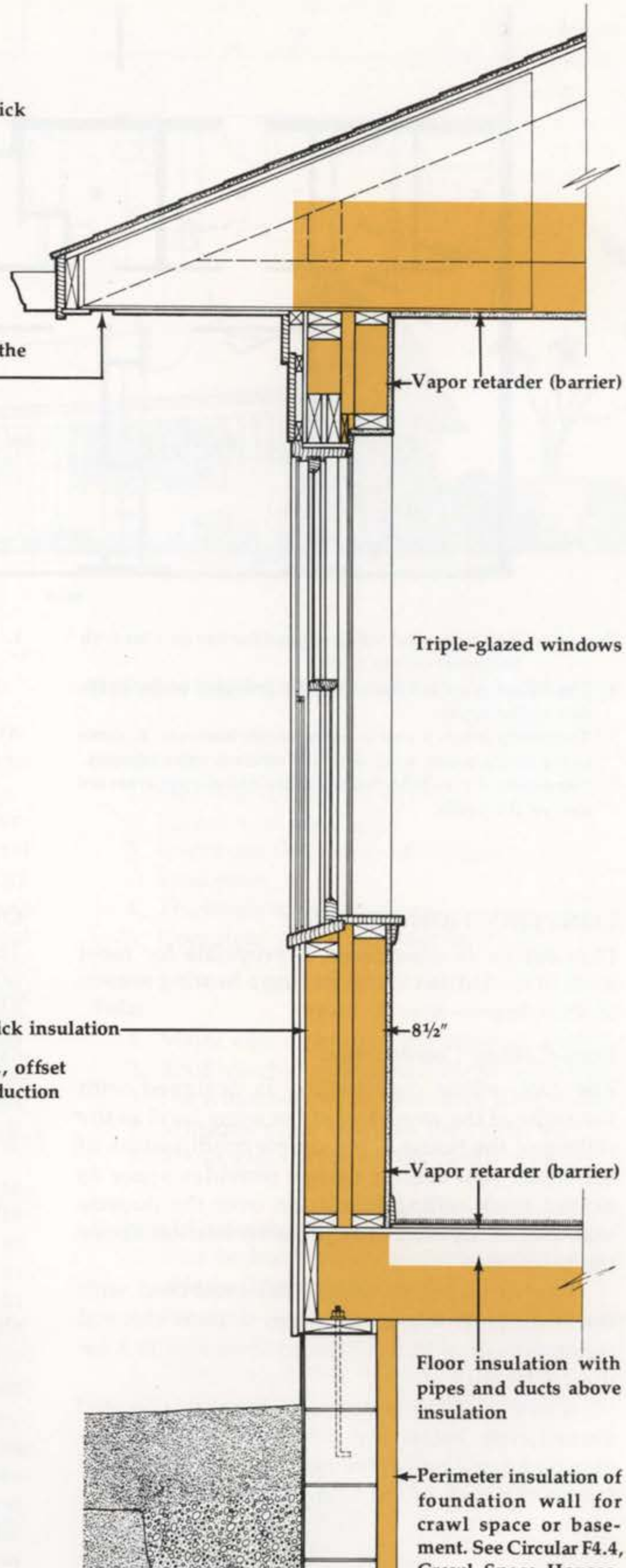
* Additional details and engineering analyses will be published in:
Technical Note 14: DETAILS AND ENGINEERING ANALYSIS OF THE ILLINOIS LO-CAL HOUSE - $7.50

Outside Wall Construction

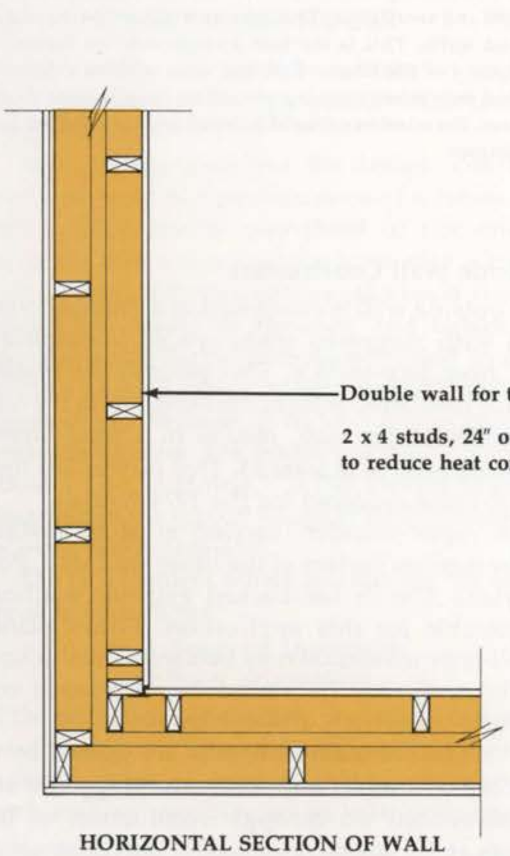
The outside wall is composed of a double-framed wall with staggered studs spaced a distance of 8½" from face-to-face. This permits the installation of insulation which, combined with the other elements of the wall, results in a total thermal resistance (R) of at least 33. This is over 2½ times the R-value required for the 1974 house.

A vapor retarder (barrier) **must** be installed at the interior surface of the inner stud wall. Polyethylene film or foil-backed gypsum wallboard is suitable for this application. Either blanket or fill-type insulation may be used. The thickness of the wall may be varied in accordance with climatic conditions and energy costs.

Several secondary benefits are gained by the use of the double wall. With the staggered-stud construction, no through conduction of heat occurs at the wood framing. During construction, electric wires can be run between the double exterior walls without drilling, thus reducing the labor cost of electrical installation. The slot between the top plates of the wall permits venting of water vapor to the attic space. The thick, insulated wall and triple-glazed windows will reduce sound transmission.



VERTICAL SECTION OF HOUSE



HORIZONTAL SECTION OF WALL

Floor-Foundation Insulation

The most effective method of reducing heat loss through the floor is to insulate both the floor of the house and the perimeter wall of the fully-enclosed crawl space. The Lo-Cal design uses R-19 insulation in the floor, and R-10 insulation on the perimeter wall of the crawl space. With this insulation, heat loss through the floor never exceeds 1 Btu per sq. ft., and the crawl-space temperature is generally above 45 F. When practical, hot-water pipes and heating ducts should be installed above the floor insulation; otherwise, they should be insulated.

Window Design

The triple-glazed windows of the Lo-Cal House are designed for low heat loss and high solar gain in winter, and low solar gain in summer. The design is based on a study which shows that the solar gain minus heat loss of south, triple-glazed windows averages 200 to 400 Btu per sq. ft. per day (see page 6, "Solar Mechanics"). In the one-story plan, 85% of the window area is on the south wall, and in the two-story design, all windows may be south. Small windows on other walls may be desired for view.

Triple-glazing consists of a standard window with sealed insulating glass plus a storm window with removable screen. For the Lo-Cal House a double-hung window with a height of 50" was selected. This height correlates with a roof overhang which is located 16" above the window and extends outward 30" to the edge of the gutter. The south windows are exposed to sunlight in the winter, and are shaded in the summer. In late summer and early fall, when the roof overhang shades only the upper part of the window, more shading can be provided by shade screens or other devices. Since the house is so highly insulated, the 122 square feet of south windows provides optimum solar gain (see page 7, "Performance"). This south glass area is about 8% of the gross floor area of the house.

TABLE 1
DESIGN HEAT LOSS
(Btu per hour)

Components	Lo-Cal House	1974 house
Ceiling (1568 sq. ft.)	2980	5960
Wall (1160 sq. ft.)	2670	6960
Floor (1568 sq. ft.)	1570	3140
Window (144 sq. ft.)	4000	7020
Doors (40 sq. ft.)	200	200
Infiltration (½ air change per hour)	8470	8470
Total design heat loss	19890	31750

Note that the infiltration loss, based on ½ air change per hour, is assumed the same for both houses. Note also that for the Lo-Cal House, the infiltration loss accounts for over 40% of the total loss.

Heat Loss Calculations

Table 1 summarizes the heat losses for the five component surfaces and infiltration for the Lo-Cal House and the 1974 house. These calculations are made in accordance with accepted engineering practice, and do not include solar gains or internal heat gains.

Heating System

In the weather simulation for Madison, Wisconsin (1961), the maximum heat loss of the house is computed to be 16,530 Btu per hr.; the maximum heat loss for a day is 240,000 Btu. A number of options are available for the heating system.

The simplest system with the lowest cost would be individual room electric heating, such as baseboard units located under the windows. These units would have a total rated output of only 6 kilowatts, and the advantage of individual room thermostatic control.

Cooling System

For mechanical cooling, small **individual room units** could easily carry the load. Although these units offer the advantage of individual room control, they are noisier than a central cooling system.

A **central system** using an outdoor air-cooled compressor can be provided at a fairly low cost. The cooled air would be distributed through an overhead duct located in the main hall. At a higher cost, the air-handling system can be designed to bring outdoor air into the duct system.

For the daily cooling load of 142,000 Btu, a central unit with a cooling capacity of 8000 to 9000 Btu per hr. would suffice on most days. A larger unit would handle those times when the hourly load is extreme, but the normal operation would be intermittent; as a result, the relative humidity would fluctuate and be uncomfortable. Better comfort is obtained from an air conditioner which is slightly undersized so that the compressor and the fan operate continuously.

If occasional unusually large internal heat gains are anticipated, as from a large gathering of people in warm weather, an auxiliary cooling unit would be desirable.

Exhaust Fans

Kitchen and bathroom exhaust fans, either manually or automatically controlled, will remove excess heat and moisture generated by cooking and bathing.

Solar Mechanics

Sunlight through the windows heats the interior surfaces of the house; the structure and furnishings absorb heat and warm the air; insulation retains warmth in the house, even after sundown. With maximum insulation and major south windows of insulating glass, the **house itself becomes an efficient solar collector.**

The net heat gain (or loss) of a window varies with the latitude, month, window orientation, solar transmission and heat transmission, outdoor temperature, atmospheric conditions and percentage of sunlight, reflected sunlight, and shading of the window. With the seasonal change of sun angle, the **solar gain of south windows** is highest of all in winter, moderate in spring and fall, and low in summer.

The average daily solar gain of a **south triple-glazed window** exceeds the average 24-hour heat loss through the window; this net heat gain is about 200 to 400 Btu per sq. ft. per day during the heating season. In some regions with more sunshine and snow cover, the heat gain may be much higher. Generally, this benefit of solar heating by south triple-glazed windows applies to the cold climates of the United States. In the moderate winter climates, with less than 4500 degree-days, **south double-glazed windows** have similar benefits.

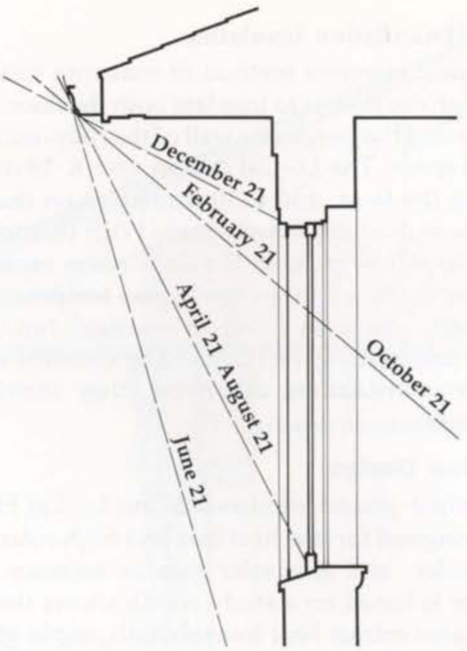
Shading of Windows. While the south windows provide solar heat for the house from October to April, the windows should be shaded to minimize solar gain from June to October.

a) **Trees.** Deciduous trees are most useful because they are in leaf during the warm season of the year when shading is desirable. They do not interfere with winter solar gain since their leaves have fallen prior to the heating season.

b) **Roof Overhang.** With the seasonal change in sun angle, the roof overhang above the south windows can be designed to achieve the amount of shading or sun exposure desired.

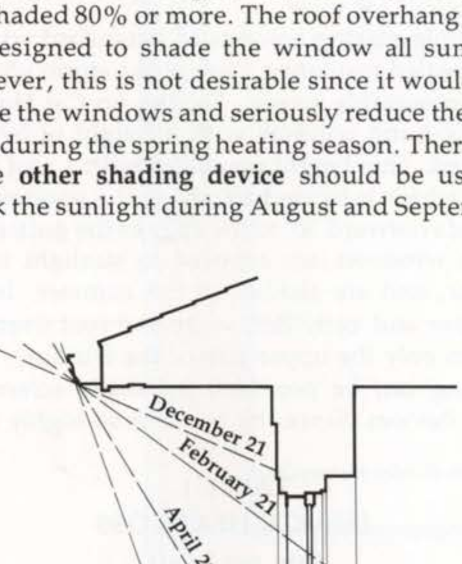
c) **Other Shading Devices.** Awnings, shade screens, shutters, blinds, foils, or draperies can limit solar gain of windows. For example, in conjunction with a roof overhang, shade screens over the lower half of windows can stop most of the solar gain of south windows in August and September.

The illustrations show sun angles for latitudes of 39° and 43° with the profile of the roof overhang and south window of the Lo-Cal House. At 43° latitude, the south windows are over 90% exposed to the sun from October 21 to February 21.



Shading of south windows at 39° latitude (Colorado Springs, CO; Kansas City, MO; Cincinnati, OH, Washington D.C.)

From April 21 to August 21, the south windows are shaded 80% or more. The roof overhang could be designed to shade the window all summer; however, this is not desirable since it would also shade the windows and seriously reduce the solar gain during the spring heating season. Therefore, some **other shading device** should be used to block the sunlight during August and September.



Shading of south windows at 43° latitude (Casper, WY; Madison, WI; Buffalo, NY; Manchester, NH)

PREDICTED PERFORMANCE

Design Conditions

Calculations of energy requirements for both the Lo-Cal House and the 1974 house are based on the same conditions of weather, range of internal air temperature, air infiltration rate, and internal gains. In the 1974 house, the windows were placed with one-third of the total window area on each of the north and south walls and one-sixth on each of the east and west walls.

Comfort Conditions

For both houses, the room-air temperatures were permitted to vary within a range of 68 F to 78 F. Most people will accept air temperatures a few degrees above or below 72 F, especially when energy is saved.

Winter Performance

Actual heating costs for the Lo-Cal House can be verified only by building and testing a demonstration house under controlled monitored conditions. Full-scale confirmation of predicted results would require the building of a large number of lived-in houses in widespread areas of the United States and Canada.

The heating analysis of the house can be expressed as:

HEAT INPUT = HEAT LOSS

The **heat inputs** are: (1) **internal gains** from persons, lighting, refrigerator, range, television, water heating, etc., (2) **solar gains** principally from windows, and (3) **input from heating system** which uses fuel or electricity.

The **heat losses** are made up of: (1) transmission losses through the house shell (ceiling, walls, windows, doors, and floors), and (2) infiltration. Since as yet no demonstration house of this design is available to measure actual performance, the only recourse is to make a thorough engineering analysis, taking into account all energy inputs to the Lo-Cal House. For this purpose, a mathematical model* was utilized and weather data (1961) for Madison, Wisconsin, were arbitrarily selected. The degree-days for the locality amounted to 7564 DD for 1961. In this analysis, the assumed internal heat gain was from two persons, plus an internal heat gain equivalent to 10 kwh per day, which amounts to 51,000 Btu per day. The computer analysis is summarized in Table 2.

* U.S. Army Corps of Engineers, Construction Engineering Research Laboratory "Thermal Loads Analysis and Systems Simulation Program."

TABLE 2
SUMMARY OF HEAT LOSS AND HEAT GAINS
(All units are in millions of Btu per season)

Losses or Gains	Lo-Cal House	1974 house
Annual Heat Losses (Sept. 15 - May 30)	40.3	61.9
A. Internal Heat Gain	13.1	13.1
B. Net Solar Heat Gain	14.3	10.8
C. Input Required from Heater	**12.9**	**38.0**
D. Total Gain and Input	40.3	61.9

In order to heat the Lo-Cal House for a year, the owner would need to buy:

129 gallons of fuel oil, or
174 therms of natural gas, or
3806 kwh of electrical-resistance heating.

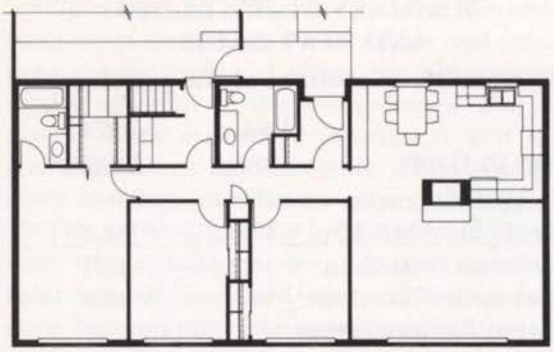
The owner of a house built to current (1974) standards would have to buy about three times the above amounts each heating season; the fuel requirements for a 1950 house would be even higher.

Summer Performance

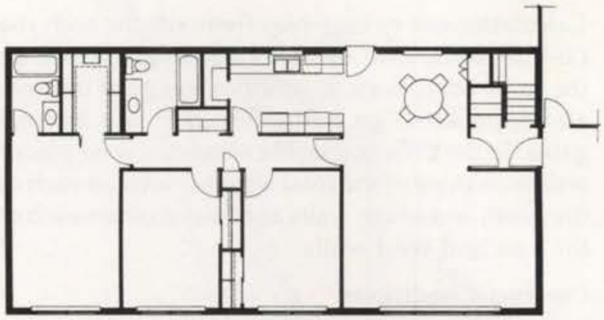
Due to the superior insulation, the Lo-Cal House gains heat very slowly and the summer cooling load is never very high. With the assumed internal heat gain of 51,000 Btu per day, the maximum cooling requirement is approximately 142,000 Btu per day in the Madison, Wisconsin, climate. For energy conservation, internal heat gains should be kept as low as possible during warm weather. For example, a large gathering of people in the house would substantially increase the cooling load.

For the purpose of the computer analysis, the cooling season was considered to be from May 1 through October 31. The total cooling load (including internal gains) for the period was computed to be 8.3 million Btu. Assuming that 1 kwh of electricity will deliver at least 6000 Btu of cooling, the energy required for cooling would be approximately 1400 kwh. At 4 cents per kwh, the cost for cooling would be $56 for the season. This cost could be reduced by using additional shading of the south windows during August and September, and could be further reduced by using night air cooling when the outdoor air temperature and humidity are suitable.

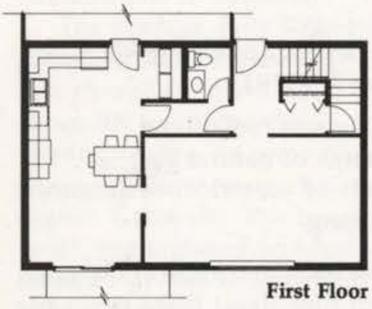
ALTERNATE DESIGNS



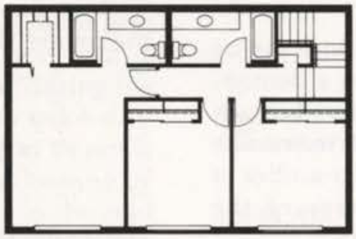
Design B. **This incorporates a basement and a fireplace in the basic design. Double sliding glass door units can be used instead of windows.**



Design C. **This is more appropriate when the street is on the south or east of the lot. The entrance is moved to the end of the house and the garage is relocated.**

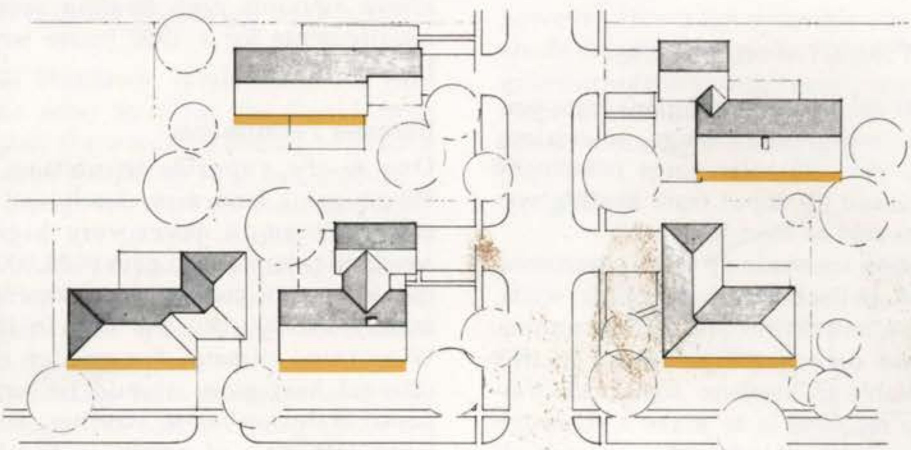


First Floor



Second Floor

Design D. **This plan shows how the principles may be applied to a two-story dwelling unit.**



Variations in Plot Plan.

The principles demonstrated in the design of the Lo-Cal House can be used in the design of all types of housing.

The plot plan shows the use of the various designs in a typical subdivision having a rectilinear street pattern. It is obvious that monotony and sameness need not be a problem.