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Energy in Agriculture: Planning a House With an Energy Future

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ENERGY IN AGRICULTURE

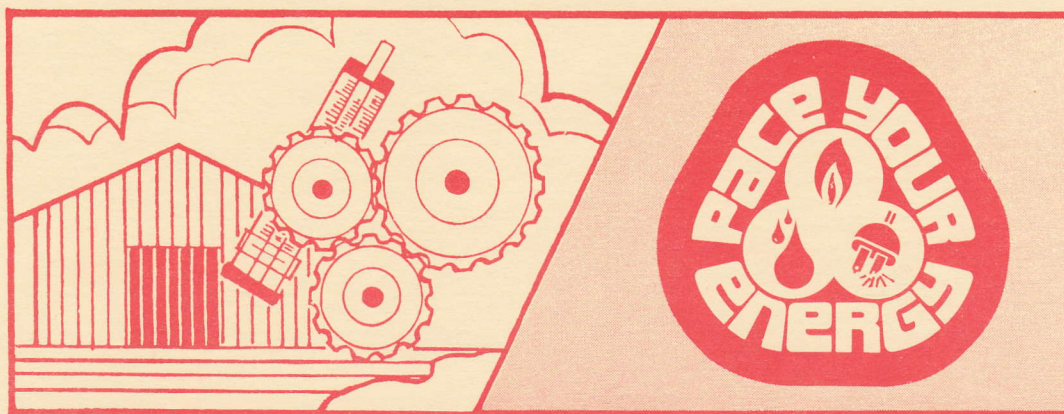
Planning a House With an Energy Future

by

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UNIVERSITY of KENTUCKY
COLLEGE of AGRICULTURE
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COOPERATIVE EXTENSION SERVICE

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Planning a House With an Energy Future

Introduction

If you are planning a new house, consider the following. Suppose the price of energy for residential space heating and domestic water heating doubles or triples during the next 10 years. Will your new house be prepared for such a future? Have you given the energy required to operate your home equal importance to building site, style, floor plans and construction materials?

Even if the price of heating fuels does not increase rapidly in the near future, you would be wise to incorporate plans for energy use in your design. With careful planning it is possible to build a house today that will use as little as 10 percent of the fossil fuel required by most residences constructed 10 years ago. This house need not be prohibitively expensive. However, you will need to plan for the many items that relate to energy needs. A careful observation of air infiltration, insulation, site selection, building orientation, exterior style, equipment selection and utilities can significantly enhance the energy future of your new house.

Site Selection & Building Orientation

Solar energy heats all houses to some extent. Unfortunately, in many instances this heating occurs during the summer when you do not need it. Often it is not feasible to effectively utilize solar heating during winter months in existing housing because the builder did not plan for solar energy when selecting the site and building orientation. You need an unobstructed southern exposure to take full advantage of the low winter sun for cold weather heating. Thus, the site selected should not be bordered on the south side by tall structures or evergreen trees that will interfere with wintertime use of the sun between 9 a.m. and 4 p.m.

The site should permit an east-west building orientation (Figure 1). This will allow use of the south side of the building for either passive or active solar collection. Locating the building on the north side of the site will provide some protection from future construction south of your site. An east-west orientation can also reduce summertime cooling requirements. During the summer most solar radiation will strike the east and west walls and the roof. Thus, there is a smaller cooling requirement for

houses with a small proportion of east and west wall areas compared to north and south walls.

Save those deciduous trees! Take advantage of existing trees on your building site. Shading by deciduous trees can eliminate much of the direct solar radiation in the summer, while permitting you to utilize this energy for heating in the winter.

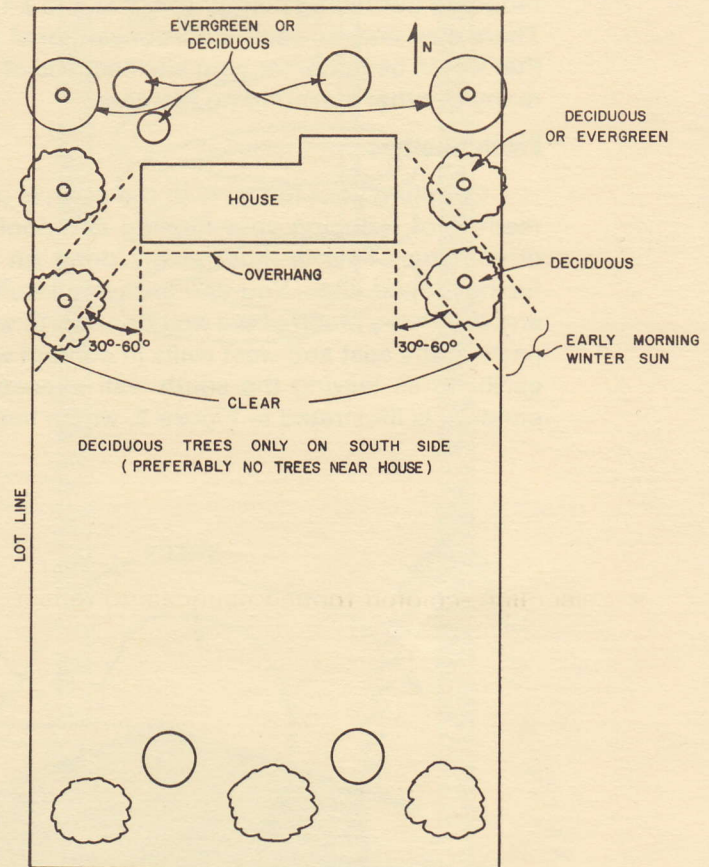


Fig. 1.—Plot plan illustrating a southern area that is clear of trees to accept winter sun. Trees on the east and west block summer sun from east and west walls. The roof overhang and deciduous trees on southeast and southwest will block most of the summer sun from the south windows.

Exterior Style

Shape

The shape of a house can have a significant impact on heating and cooling requirements. Generally, a house elongated along the east-west axis

will have lower heating and cooling requirements than a square house or one elongated along the north-south axis. The house should not be long and thin since this would result in a large outside wall area per unit of floor area. While a square house will have less wall area through which to gain or lose heat, the added solar gain through a large south-facing wall in winter and reduced gain through small east and west walls in summer will usually offset the area advantage of the square design. You can reduce the outside wall area by 7.7 percent by reducing the ceiling height from 8 feet to 7 1/2 feet. There also may be some non-conventional shapes that would be better for your site because of topography or other surrounding features.

Earth Shelters

Coupling your house with the earth is another method of reducing your heating and cooling requirements. This is most easily done on south-facing sloped sites. You can excavate into the hill and thus have much of the first floor north wall and parts of the east and west walls in contact with the earth, while leaving the south wall exposed. The concept is illustrated in Figure 2, which features a

house with approximately two-thirds of the first floor walls and the concrete floor exposed to the earth. These earth-coupled areas will serve to decrease the cooling load during the summer, and with R10 insulation will be approximately as good as an R20-insulated wall above grade during winter. Such a residence, which is well-shaded with deciduous trees, will be relatively comfortable during the summer without an air conditioner. You would need to open windows at night and close them during the day, and use a fan to circulate air from the basement level to the upper level. If you air-condition such a house, the cooling requirement will be low.

If you cover the entire wall with soil, you should place the insulation on the outside wall and extend it to the foundation. Use at least 2 inches of rigid insulation. If you cannot insulate part of the wall on the outside, for example, if part of the wall is above ground, insulate the wall on the inside. Again, the insulation should extend to the floor. When the floor is within 2 feet of grade level, you should place 2-inch thick rigid insulation below the concrete around the edge. It should extend under the concrete at least 3 feet. You should also insulate the edges of the floor from the wall or footer.

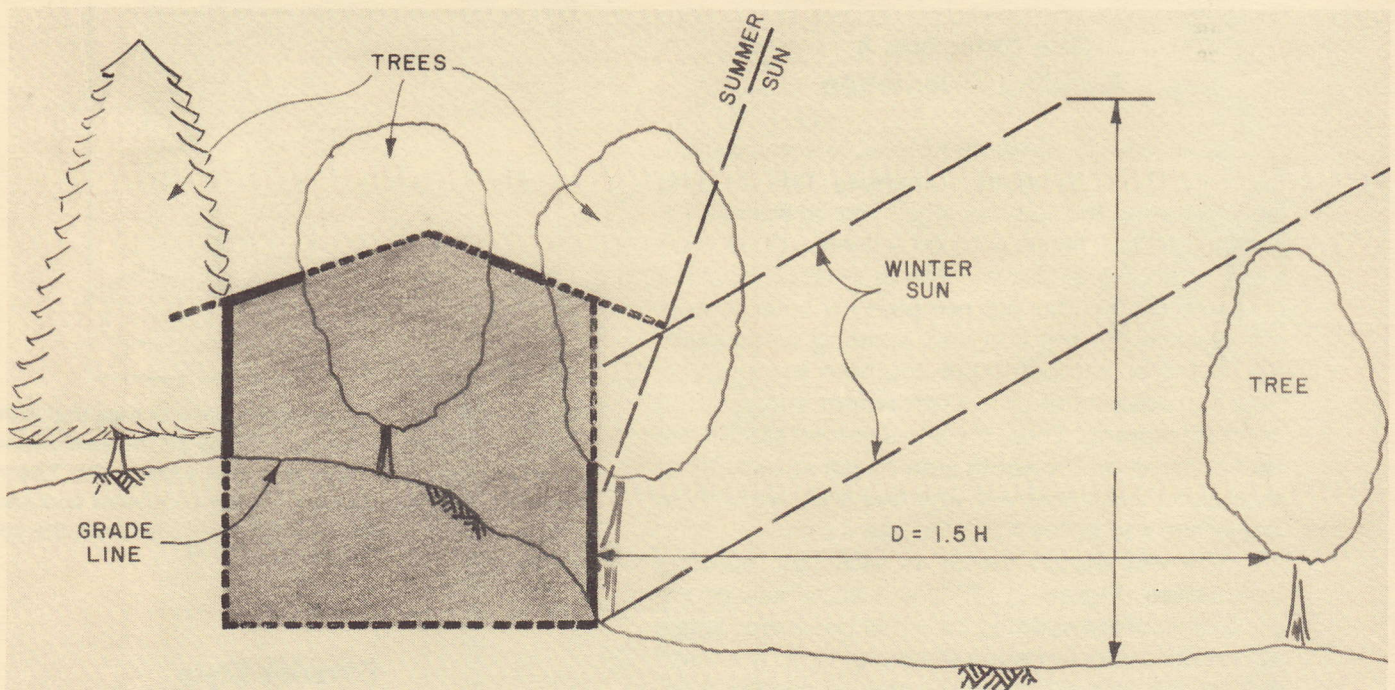


Fig. 2.—View of house from west shows deciduous trees to shade west side of house. Trees on the south are located a distance of 1.5 times mature tree height from the house. The earth berm provides earth contact for about 65 percent of the first floor walls. Overhang shades most of the south wall during summer.

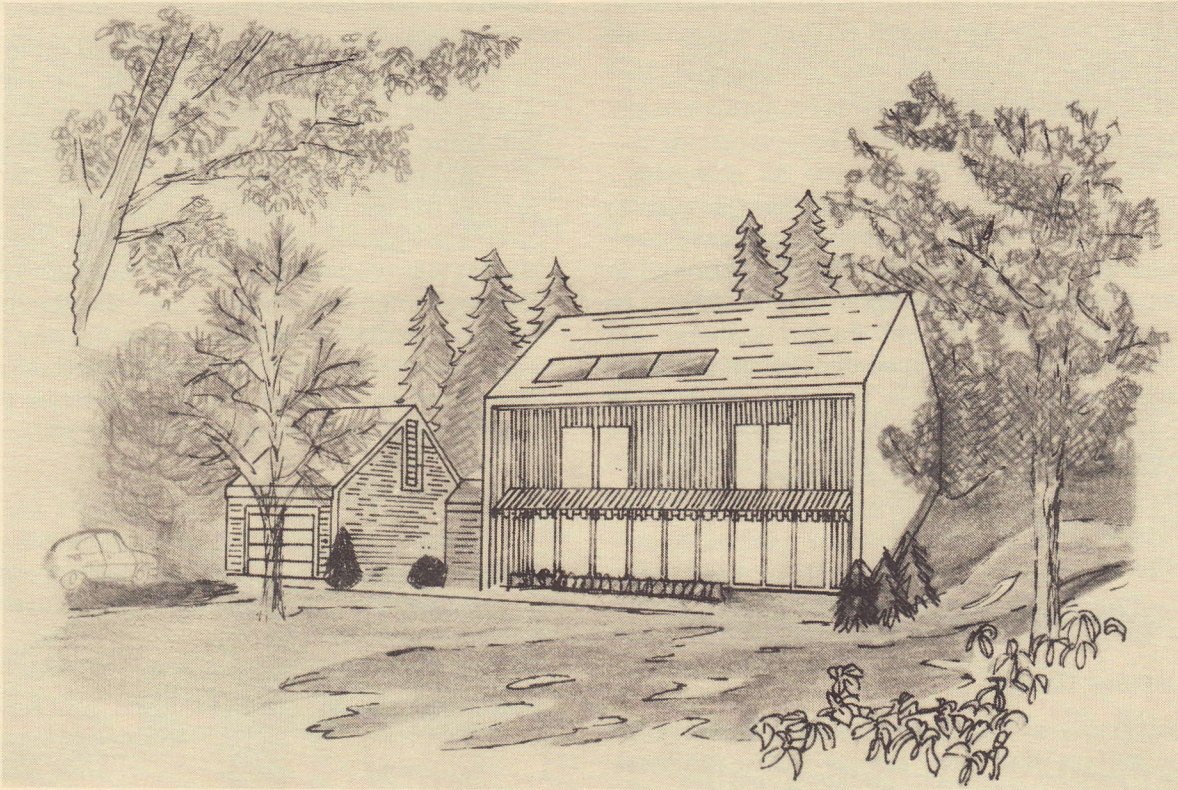


Fig. 3.—Windows on the south side of a residence are probably the most economical method of solar heating. The overhang should shade most of the glass in summer and shades or drapes (preferably an insulated type) are necessary to reject unneeded solar heat in summer and to decrease heat loss in winter. More windows are used on the earth bermed first floor since heat storage mass (masonry floor and walls) can be provided inexpensively.

Passive Solar Heating

Direct Solar Gain

Plan to partially heat the building by utilizing passive solar heating. Place more than half of the window area on the south wall and little or no window area on the east, west and north walls (Figure 3). Locate a heat storage mass, such as a concrete or tile floor and concrete block walls, so that sunlight will hit these areas. The floor and walls will be helpful in reducing temperature fluctuations inside the house since they absorb solar heat entering through the south-facing windows. With a large mass for heat storage, the temperature will rise only a few degrees (preferably less than 5 degrees) when the sun is shining. When the sun is not shining, the temperature will drop a few degrees, and the walls and floor will give up heat to the room. Without some heat storage mass in direct sunlight, a large southern glazed area will result in a large temperature fluctuation.

Sunlight admitted to the house through the roof is another method of passively heating with solar energy. This can be done by using skylights or clerestories (windows under a roof projection at the roof peak). This method can be particularly effective when the building site dictates that the house be elongated along the north-south axis rather than the more desirable east-west axis. However, these methods need triple-pane glazing in Kentucky, and they require shading or movable insulation in order to avoid overheating in summer. They are not as economical as south-facing windows.

Thermal Storage Well

Consider building part of the southern wall of 12-inch concrete block filled with concrete; paint the outside black and place double glazing on the surface. Most of the extra cost will be the glazing, and the heat gain will equal the uninsulated double-pane south-facing windows. In addition, the heating will be better distributed during the day, and direct

sunlight will not fade fabrics. Insulating the exterior glazing when the sun is not shining will provide significantly more heat but such insulation is more difficult to provide than windows.

Shading

You should provide means of preventing solar radiation from entering windows to decrease cooling load during the summer. You can accomplish this most easily by designing the roof overhang so that openings are shaded during summer but receive full sunlight during winter. Deciduous trees can also be very helpful in reducing direct solar gain. Occasionally it may be desirable to utilize movable shading devices. Shades or draperies with white external surfaces will reflect much of the diffuse and direct solar rays.

Construction Methods & Materials

Air Leakage Control

Excessive air leakage can cost you all of the gain obtained from other energy-saving practices. Be sure to weatherstrip all doors and windows and use caulking at all construction joints (under sole plates, around door and window frames, etc.) to prevent air leakage. You should also place a tightly fitted 6-mil plastic vapor barrier inside the insulation on walls and ceiling and use tight dampers on fans, fireplaces and vents. As you reduce the naturally occurring air exchange between your house and the outside, you must provide for adequate ventilation. Gas furnaces and water heaters, fireplaces and wood-burning stoves all require oxygen to support combustion. It is important to provide outside air for combustion when you have minimized air leakage. You should also be aware that in some cases inadequate air exchange in excessively tight houses has aggravated wintertime respiratory illnesses. It may be desirable to install an air-to-air heat exchanger to provide a fresh supply of air.

Draperies

Draperies should be white or aluminized on the outside face so that they will reflect sunlight when closed. During summer, large glazed areas should have the drapes closed even if the window is shaded from direct sunlight since the ground reflection plus diffuse sky radiation may be as much as 30 percent of the direct solar radiation.

Insulated Windows

All windows should be double- or triple-glazed to reduce heat gain or loss through the glass. You should use interior or exterior insulating shutters or insulating drapes on all windows. Insulated shutters and drapes are effective only if they close tightly around the window space so that room air cannot circulate against the glass. Insulated drapes and shades with magnetic or Velcro® seals are available. During winter you should open the south-facing window shutters or drapes during the day to allow solar radiation to enter and then close them at night to prevent heat losses. You should close them on summer days to prevent radiant heat gain.

Wall and Ceiling Insulation

Use 6-inch studs or a double row of 4-inch studs in the outside walls instead of conventional 4-inch studs (Figure 4). This will permit you to use 5 1/2 to

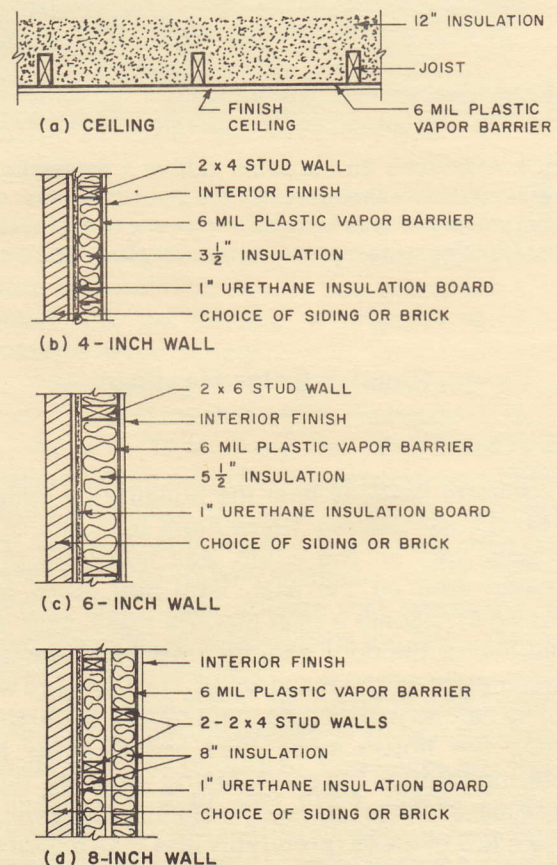


Fig. 4.—Suggested wall and ceiling construction with good to super insulation. R values for the ceiling and wall sections are: (a) 41, (b) 22, (c) 30 and (d) 39° F ft² hr/Btu.

8 inches of batt-type insulation in the exterior walls. Place the equivalent of 12 inches of fiberglass in the ceiling. Extend the ceiling insulation over the outside wall plate (Figure 5). This combination can significantly reduce your heat gain or loss compared to conventional practice. It may be necessary to use a spacer in roof trusses at the eave so that you can install 12 inches of insulation with 2 inches of air space above the insulation.

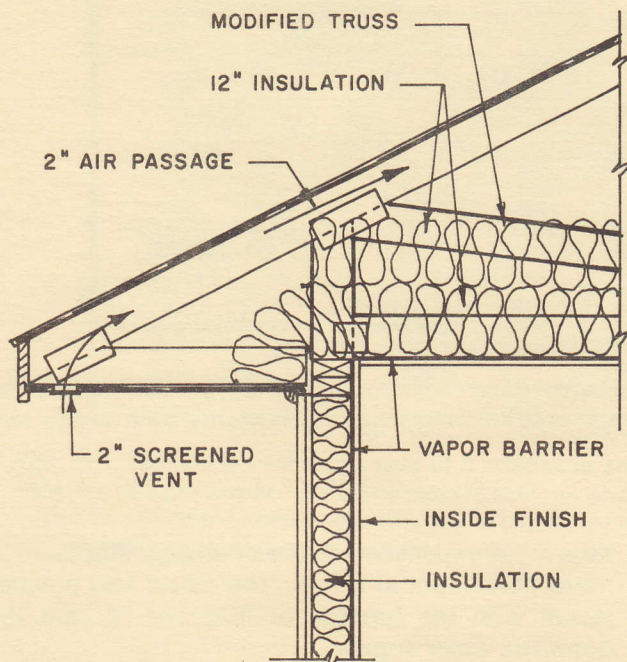


Fig. 5.—Rafters should be at least 8 inches above the plate to provide space for the ceiling insulation to extend over the plate.

Exterior Colors

Light-colored roofing materials and outside wall colors reduce solar radiation absorption and dark colors increase absorption. The influence of absorbed solar radiation on heat flow through the walls and ceiling depends on insulation. For a super insulated house the outside color of surfaces will have practically no effect on either heating or cooling energy requirements. However, for poorly insulated (4 inches in ceiling and 2 inches in walls) buildings, light-colored exterior surfaces will reduce cooling loads, while dark surfaces on roofs and southern walls will decrease heating loads.

Floors and Walls

When using windows on the south wall for passive solar heating, use masonry floors and walls to store heat if the window area exceeds 20 percent of the floor area. Use tile floor covering without carpeting so the radiant energy can be readily absorbed and stored in the floor.

Interior Style

Space Location

Plan the location of activity areas according to comfort requirements when in use. Place living area spaces that are heavily used during the day along the south side of the house to make more effective use of passive solar heating (Figure 6). Place rooms that are not heavily used or that can be utilized at lower temperatures (garage, utility room, formal living room, etc.) around the heavily used area to serve as a buffer to the outside.

Zone Heating and Cooling Controls

Careful grouping of activity areas can make it possible to decrease heating or cooling requirements by using zone control. You can achieve zone control of a hot-air heating system by closing vents in areas that you do not wish to heat, and you can restrict air flow by partially closing vents when you require only a small quantity of heat.

Heat pumps and air-conditioning units must be designed and constructed for zone control if you plan to use the vent-closing method. Each heat pump or air-conditioning system has a minimum air flow that must be maintained over the cooling coils or damage may result. These systems should be designed so that you can direct the total required air flow to those rooms that will always be conditioned. You should make provisions to restrict air flow to those rooms when vents are opened in other areas of the building.

Utilities

Plumbing

Plan to place all plumbing near the south central area of the house, which is continuously heated (Figure 6). Place the water heater near the points of most hot water use. The water heater and

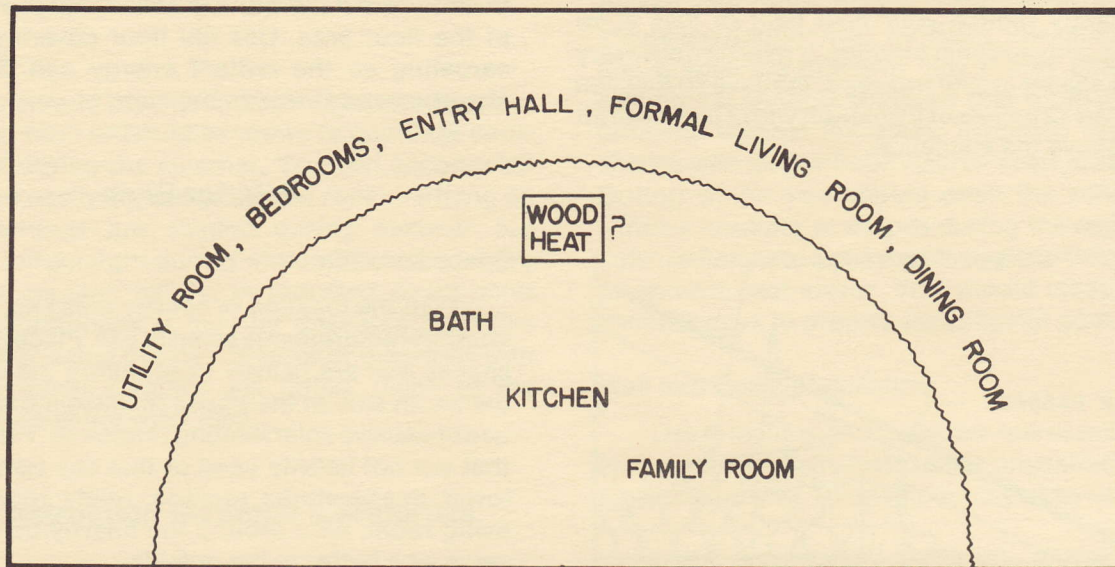


Fig. 6.—Locating all plumbing in a centrally heated area saves on plumbing construction and heating. Other rooms may be heated on a part-time basis or heated to a lower temperature. Plan to heat only those rooms needed by installing zone control of heating with doors between zones.

all hot water pipes should be well insulated. These items will help you reduce heat loss from water as it goes from the water heater to the use point and minimize the cost of plumbing during construction.

Solar Water Heating

One of the most economical solar heating uses is for domestic hot water. If the alternate fuel is high priced and you can take advantage of the 40 percent Federal Tax Credit, then active solar heating of the domestic water supply might be economically feasible using a manufactured system (Figure 7). If you are sufficiently skilled and are willing to learn enough about solar heating, you may be able to carefully construct a part of your own solar water heating system. But proceed with caution! A poorly designed or constructed system can easily be a failure and cause more problems than solutions.

Wood Furnaces and Fireplaces

If wood is available on your property or you can obtain it locally for the effort of cutting and hauling, a wood-fired furnace or stove might be the most economical heating system. Purchased wood may

be a more expensive source of energy than are the more conventional forms. You could use a water jacket with the furnace or fireplace to heat the domestic water supply.

The chimney for wood furnaces and fireplaces is usually best located within the house rather than at one end. This allows the heat loss from the chimney to remain in the house rather than be lost to the outside. Also, for low-draft furnaces and stoves, the soot and tar buildup in a chimney constructed within the building will usually be less for a chimney constructed on the outside wall since an outside chimney cools and condenses the flue gases more than an inside chimney.

You should install tightly fitted glass doors on fireplaces to prevent excessive air being exhausted up the chimney (Figure 8). Fireplaces are not very efficient and often use more energy than they provide when there is no draft control. Always close the glass doors at night to reduce warm air loss from the house. In addition, close dampers when the fireplace is not in use; most glass doors do not fit tight enough to prevent air loss. Poor management of the operation of a fireplace can very quickly offset any potential energy savings.

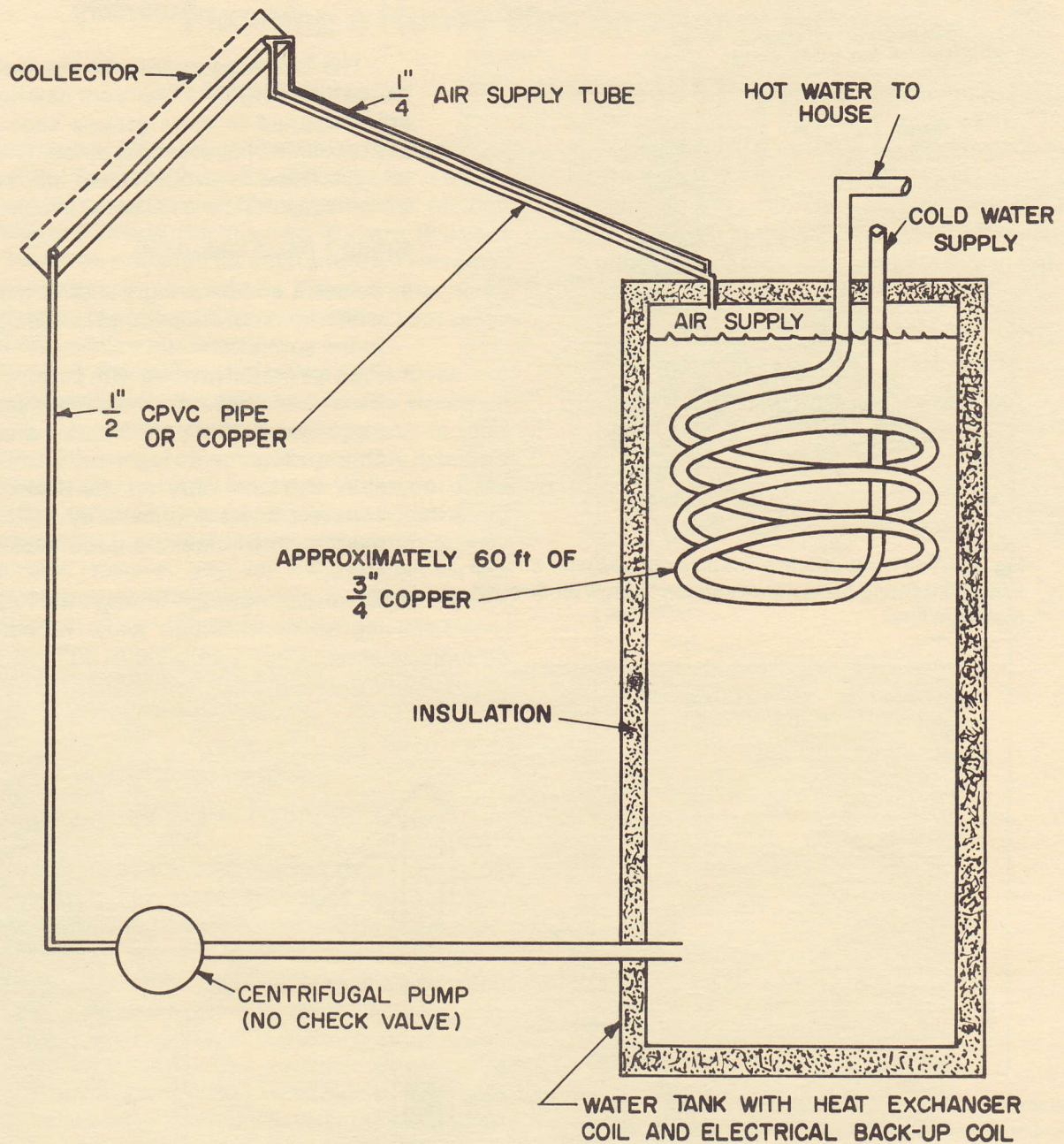


Fig. 7.—An active solar domestic water heater should be considered especially if the fuels available are high cost. This solar unit is a closed drain-back system that should avoid corrosion. Antifreeze is not required.

Active Solar Heating

Residential space heating is probably best accomplished with the air-type solar heating system. If an active solar heating system is not installed when

your home is constructed, provision for a future addition can be made by including a roof with an area at least 25 percent of the floor area and a southern slope of approximately 45 degrees (Figure 9).

Summary

The following energy-saving features will enhance the energy future of your new home. Features are presented in three groups according to their approximate order of importance. The most important are listed in Group 1, and the least important but still desirable are listed in Group 3.

Group 1 (Most important)

- Select a south-facing building site (if possible with a southern slope) that is free of obstructions to the south.
- Plan for partial heating with passive solar energy. Face your longest and tallest wall south and place more than half of your window area in this wall. One arrangement might be a two-story south-side with one story on the north. Tile-covered concrete floors and masonry walls on the basement level will make a good passive solar heat storage.
- Control air leakage through the house by caulking all construction joints (under sole plates,

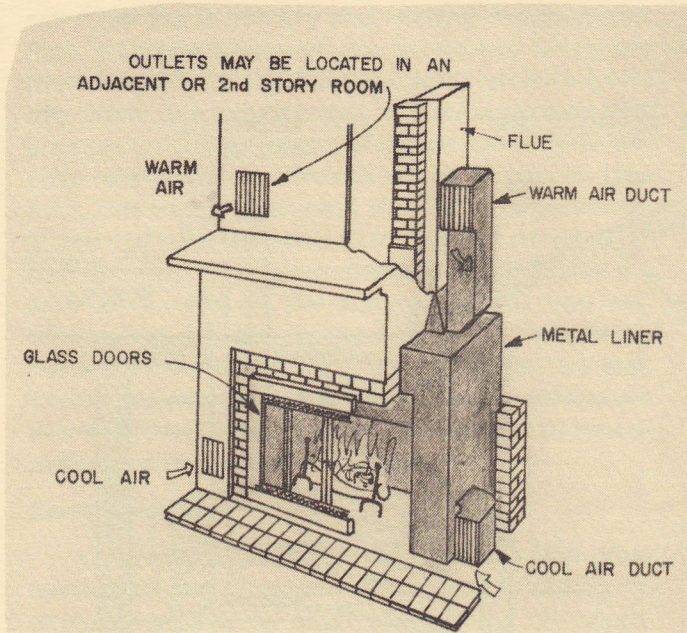


Fig. 8.—The most efficient fireplace is one with a metal liner, tight fitting glass doors and fan to blow air through the metal liner.

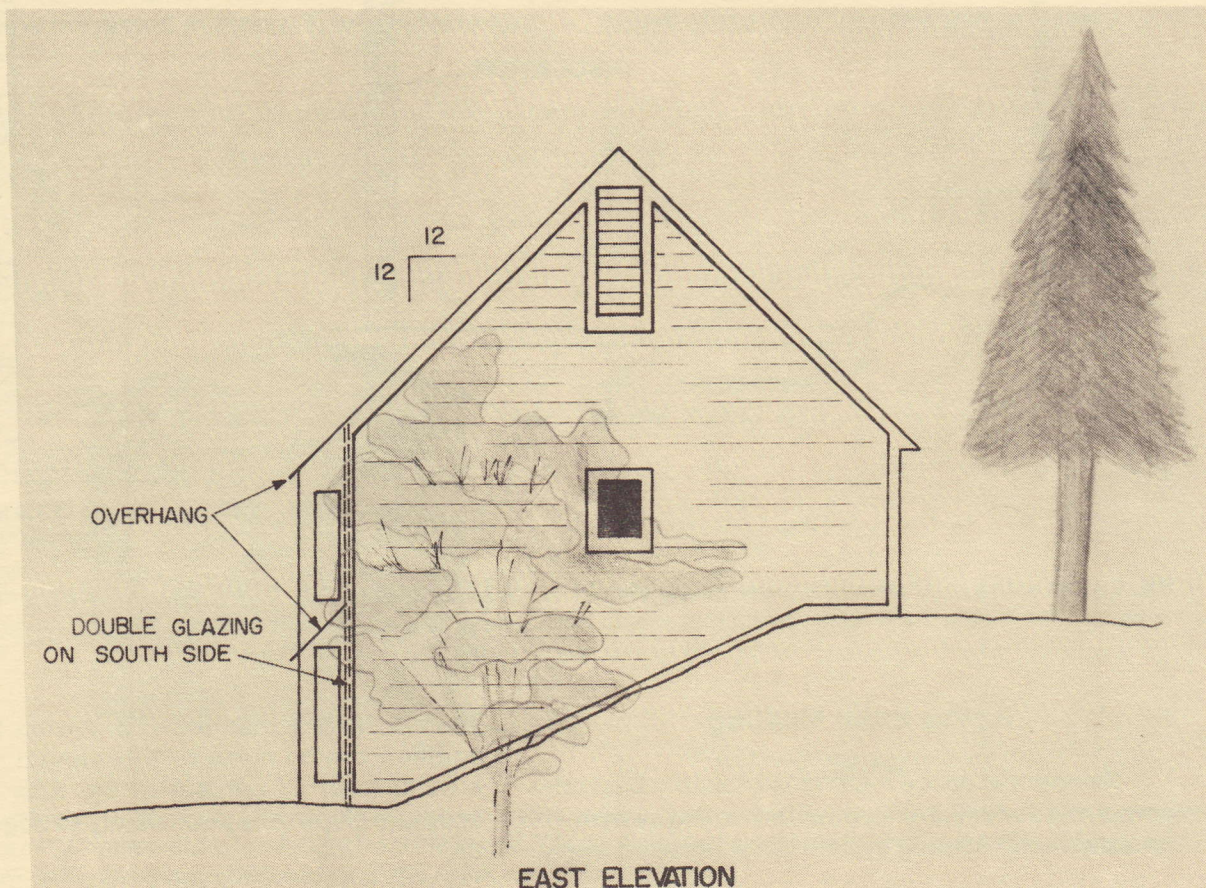


Fig. 9.—A 12 in 12 roof slope (45 degrees) is satisfactory for installing active solar domestic water heating or house heating collectors either during construction or in the future.

around doors and window frames, etc.); using a tightly fitted plastic vapor barrier inside the insulation; weatherstripping all doors and windows; and using foam-faced cover plates for electrical outlets and tightly fitted dampers on fans, fireplaces and vents.

- Use 6-inch studs or a double row of 4-inch studs to provide space for more insulation than can be used in the conventional 4-inch wall. Use insulating-type sheathing. Use the equivalent of 12 inches of fiberglass in the ceiling.
- Use double- or triple-glazed windows.
- Use airtight fireplace inserts or install glass doors and flue dampers on all fireplaces to reduce air loss up the chimney.
- Use outside combustion air for fireplaces and furnaces.

Group 2

- Locate your building on the north side of the building site and orient the long axis in an east-west direction.
- Take advantage of existing deciduous trees and plant additional ones to provide summertime shade, particularly on east and west sides. Plant evergreen trees to provide windbreaks on the north, northeast and northwest sides.
- Place the residence into the ground as far as is consistent with your desired living environment.
- Design your roof overhang to shade the south wall and windows during the summer. Deciduous trees also provide shade as do movable shading devices.
- Space the roof framing above the plate to accommodate 12-inch insulation over the outside wall.

- Place active living areas that need daytime heating on the south side and toward the center of the house. Place bedrooms, garages, etc., which don't need as much heat, on the north side for use as a buffer to the outside.
- Use zone heating and cooling control so that only the portion being used is environmentally controlled.
- Place all plumbing near the center of the house to reduce heat loss from pipes, make zone heating control more feasible, and reduce plumbing construction costs. Insulate all pipes.
- Install a solar domestic water heater.
- If wood is readily available, consider an airtight wood-burning furnace or a controlled-draft fireplace. Include a heat exchanger in the wood furnace or fireplace to heat domestic hot water.

Group 3 (Least important but still desirable)

- Increase the sunlight admitted to the house by using clerestories or skylights.
- Consider insulating-type shutters placed either inside or outside the house for all windows. Close-fitting insulating drapes or shades are an alternative.
- Select light-colored roofing materials to reflect solar radiation. A medium- to dark-colored south wall will aid wintertime solar gain.
- Plan for eventual active solar collection by providing a large southern roof section sloped at approximately 45 degrees.

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