MINNESOTA TREE LINE
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Trees for Modifying Home Energy Consumption

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Using trees to modify home energy consumption is an old concept that has been revived recently. Many people believe that it is good to have trees around houses because fuel bills and cooling costs are lower or that trees lower fuel bills "as much as 40 percent" and summer cooling costs "by 75 percent." However, little quantitative information is available to substantiate these rather optimistic estimates because we are only beginning to realize the magnitude of energy savings possible by using trees as windbreaks or for summer shade. Current research indicates that windbreaks of trees can potentially reduce winter fuel consumption by 10 to 25 percent and trees used for shade could reduce temperatures in houses by 20 degrees F (11.1 degrees C) during the summer.

Since most homeowners invest in some landscaping, and a few in windbreaks, a little time devoted to planning the best arrangement and species can pay off handsomely. Such planning should begin with a knowledge of basic principles of home heat exchange.

HOME HEAT EXCHANGE

Heat exchange in a house occurs through three major processes: air infiltration, heat conduction, and transmission of solar radiation.

Air infiltrates buildings through cracks around windows and doors, and also through pores in the material of walls. Outside air is forced or drawn into the house through these openings by pressure differences caused by the wind or by differences in temperature between the inside and outside of buildings when there is little or no wind. Exterior surfaces of the house facing the wind experience increased air pressure and air enters the house through openings in these surfaces. Air passing into the house forces an equal amount of interior air out through openings facing away from the wind.

Warm interior air rises and flows out of the house through openings near the top. As this heat is convected away from or to the exterior walls, outside air is drawn into the house through lower openings creating a type of circulation referred to as a "chimney effect."

The combined effect of wind and temperature differences may cause air within a house to be completely changed up to several times per hour. Heat loss due to the infiltrating air accounts for roughly one-third of the heat loss in a typical home.

A house also gains or loses heat by thermal conduction through building materials. The rate of this conduction through solids is controlled by the thermal conductivity of the building material, thickness of the material, total material surface area available for heat flow, and temperature differences between inner and outer surfaces of the material.

Control of the temperature differences between inner and outer surfaces offers the best opportunity for reducing heat conduction. Outer surface temperature of a house is regulated by air temperature as well as wind velocity, solar radiation, and heat being conducted through the material. Full sunlight alone can raise exterior surface temperatures to levels considerably above outside air temperatures. Heat conduction generally represents from one-third to over one-half of the total heat exchange between a house and the surrounding environment.

Heat can also be exchanged in a house by transmission of solar radiation through windows or other glazed surfaces. If sunlight is received perpendicular to a single-pane glass surface, up to 90 percent will be transmitted into the interior living space. However, sunlight will be increasingly reflected by the glass as the angle of the solar bean departs from the perpendicular. Windows are also poor insulators and up to one-third of a house's heat loss can be attributed to window glass.

ROLE OF TREES

In winter, wind influences the heat exchange process of a house by causing infiltration of outside air and by convecting heat away from or to the exterior walls. Using trees as windbreaks to reduce wind velocity offers the greatest opportunity for altering home energy budgets if the trees are properly placed. Vegetational arrangements which provide shade to homeowners in summer may be detrimental in winter because even deciduous trees provide considerable shade in winter and any benefit from reduced wind velocity will be completely offset by reduced solar heating of the house. However, windbreaks located considerable distances from houses can reduce wind velocities without shading. Energy savings will then be due to reduced wind velocity and reduced air infiltration downwind from the windbreak. Remember, windbreaks will reduce air infiltration only on windy days. On calm days when air infiltration is the result of the chimney effect, windbreaks will have little or no effect on air infiltration.

Less is known about the effects of trees in summer than in winter, but in summer, air infiltration accounts for negligible or small heat gains in a house because of the relatively small temperature differences between interior and exterior air. Heat conduction and radiation transmission predominate in summer. Using trees to shade the exterior surfaces and windows of a house in summer will provide the greatest benefit to homeowners.

HINTS FOR HOMEOWNERS

The optimum arrangement of trees for year-round energy conservation seems to be windbreaks for reducing wind velocity in winter, accompanied by several large deciduous trees which shade the house in summer. Whether this optimum arrangement can be achieved will depend on vegetation already present on the site and the amount of land available for a windbreak. Houses built on forest land very often have enough trees on the property to quickly achieve the desired arrangement. When houses are built on cleared land, all or nearly all of the necessary trees and shrubs must be planted.

Windbreaks generally are located upwind from the house, perpendicular to prevailing winds. In Minnesota, prevailing winter winds, especially high winds, come primarily from the north and northwest. Local topography and structures can channel wind so that the prevailing direction in the vicinity of the house can vary considerably. Drifting snow will indicate the prevailing direction around the house and this information can be used to plan the windbreak.

The windbreak should be located upwind from the house on the north and west sides and no closer to the house than 100 feet to prevent snow pile up around buildings and on driveways. This distance will also ensure proper air cirulation during hot summer months. The rows of trees and shrubs should also extend 50 to 100 feet beyond each end of the house being protected. Where large areas of dense forest already occur upwind of the house within 300 to 400 feet, there may be no need for planting a windbreak.

The type of windbreak planted will depend on space available on your property. A single row windbreak should consist of coniferous trees, such as Black Hills spruce, Colorado spruce, white spruce, Norway spruce or white cedar planted 8 or more feet apart in the row. If more space is available, plant a dense row of fast growing deciduous trees on the outside. Select trees such as green ash, hackberry, silver maple, native cottonwood, Siouxland cottonwood, Norway poplar, or white willow. These trees will provide some protection from the wind until the conifers approach useful heights. If a full eight-row windbreak is possible, see your State Extension Forester or the nearest Soil Conservation Service or Department of Natural Resources representative for assistance. (Further information regarding the design, establishment and maintenance of shelterbelts and windbreaks can be found in Extension Bulletin 196, "Planting Trees for Farmstead Shelter," available from your local county extension office.)

Windbreaks offer advantages besides reducing wind velocity. Rows of trees and shrubs can often be used as visual screens or to reduce noise and dust pollution. And, if species of trees and shrubs are carefully selected an eight-row windbreak will provide significant food and cover for wildlife.

Summer shade is best provided by several large deciduous trees strategically located around the house. In Minnesota, the position of the summer sun ranges from about 65° above the horizon in the north to about 70° above the horizon in the south during mid-day. Trees planted for summer shade should be located on the west and southeast sides of the house and be of sufficient height to protect the house at these angles (figure 1). Exact placement of trees may also depend upon maintaining a desirable view from windows, aesthetic appeal, and avoiding utilities.

In winter during mid-day the sun is less than 25° above the horizon and shading of the house will occur largely from the tree trunks and large branches. For this reason plant only small or medium-sized trees necessary for summer shade along the southerly edge of the house (figure 2). Remember, trees too far away from the house to provide summer shade may provide significant shade in winter.

Trees for summer shade may be present on forested home sites, provided the developer can save them during construction. If the trees are to be planted, fast-growing species like white and green ash or honeylocust can be intermixed with slower-growing, more desirable shade trees such as Norway maple, sugar maple, Ohio buckeye, Kentucky coffeetree, hackberry, bur oak, linden and ironwood. The fast-growing trees will provide shade quicker and can be removed later as the more desirable trees mature.

Figure 1. Deciduous trees ensure summer shade and allow winter sun (on west side).

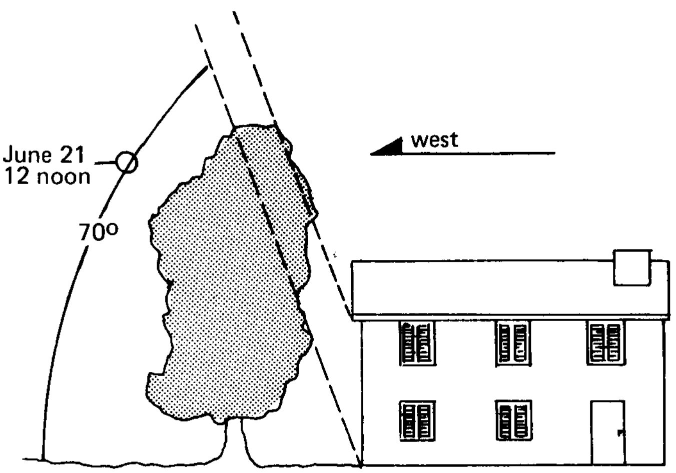
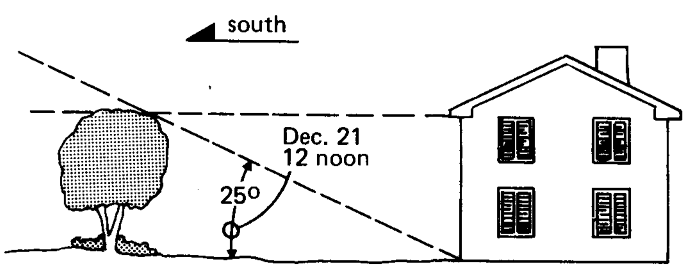


Figure 2. Tree placement to avoid shading a south wall.



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