Rochester Committee
for Scientific Information
Rochester, NY

RCSI Bulletin 243

Natural Constraints on the Use of Solar Energy

By: Mary Elizabeth Ford
November 1980

THE ROCHESTER COMMITTEE FOR SCIENTIFIC INFORMATION
P. O. Box 5236, River Campus Station
Rochester, New York 14627

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Summary

Solar collectors will work anyplace, but they will be more efficient under some conditions than others. The best site would be a gentle slope facing south where the air is clear and fog free. In Monroe County there is little fog and topography should not hinder solar system development. Cloud cover must be taken into account, but with careful planning will not prevent the successful use of solar energy.

Before installing solar systems shadow patterns should be drawn to make sure that nothing from a neighboring tree to a "Bristol Hill" will block the solar energy system. Hard decisions have to be made about which trees to sacrifice.

How Much Solar Energy Will Reach a Collector?

Topography: The Shape of the Land

In the northern hemisphere southern slopes are considered optimum for solar energy collectors even though eastern and western slopes get more sunlight during summer months. Compared to flat terrain or slopes with other orientations, the southern slope has four advantages for collectors. First, since the sun is in the southern sky, more radiation is available on a southern slope than on an adjacent flat site. Second, this southern slope orientation means that a large portion of the roof will be facing south allowing more room for collectors, skylights etc. Third, during winter roof collectors and skylights facing south (as well as those placed directly on the slope) are closer to perpendicular with the incoming solar rays from dawn to dusk than they would be if they faced toward east or west; therefore, they capture energy more efficiently. The tilt on active collectors can

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be adjusted to gain this efficiency. Finally, during the summer when the sun is much higher in the sky than during the winter (almost overhead at noon), overheating can become a serious problem for structures located on east or west slopes. This does not mean that eastern and western slopes cannot be used for solar energy collection, but only that detailed planning for shading during the summer is essential. A southern slope is also optimum because shadows are shorter at noon, thus enabling south-facing buildings to be built closer to one another, increasing overall site density, without obstructing solar access. On northern slopes, conversely, shadow lengths are longer and the radiation is more diffuse making the area which must be protected in order to preserve solar access much greater. *Slope orientation is not critical in Monroe County because our terrain is relatively flat.*

Finally, the steepness of the slope affects solar energy availability. As slope steepness increases, so do all the other attributes and/or hindrances to solar energy collection. For instance, southern slopes are warmer and have shorter shadow lengths than do other slopes; steeper southern slopes are warmer still with even shorter shadows. On the other hand, the cooler northern slopes become even colder as their gradients increase. All these considerations, of course, must be incorporated into the normal site planning process since slope steepness may place other design constraints on a site. For instance, steep slopes increase eroding potential and some towns, such as Perinton here in Monroe County, restrict or forbid building on steep slopes.

Table 1, from *Site Planning* (1) summarizes these conditions for our area of the country which it calls the "cool north."

Table 1. Site Assessment Criteria

Region	Siting Guidelines			Notes
	Best	Good	Poor	
Cool north	Sheltered sites on gently south-facing slopes.	Sheltered sites on flat ground or any slope southeast to southwest.	Exposed ridges, hillcrests, north slopes, steep west slopes, frost hollows, windy sites.	Orientation and wind shelter are the keys.

Atmospheric Conditions: Will the Sun be Able to "See" the Collector?

Sunlight is filtered by the atmosphere. The more particulate matter a given sunbeam meets in its path, the less intense its energy is when it reaches a building or collector. This explains why sunlight is less intense in the morning and evening when the path of light through the absorbing atmosphere is longest. If the atmosphere is polluted, for example, from industrial or agricultural sources, more radiation than "normal" is filtered out. Monroe County has many gray days when the sun does not seem to be shining, but atmospheric conditions will allow the successful use of a properly placed collector.

Natural conditions can also affect solar radiation. For instance, the amount of fog at a site should be assessed prior to planning a solar energy system. Fog often collects locally in small pockets and therefore one site can have a very different solar energy potential than that present at a nearby site. If a site is prone to morning fog, the solar collector should be oriented in a southwesterly direction to allow for more collection of afternoon sunlight when fog conditions are less severe. Fog is not a major consideration in Monroe County since it is heavy only in early morning and in the evening. If an area is prone to severe temperature inversions, solar access can be severely hampered by the layer of dust and smog that is trapped by the inversion interface. Inversions are not common occurances in this area except near Lake Ontario.

Shadow Casting Objects

Shadows lower the efficiency of solar collectors in two ways. First, the overall amount of sunlight collected is reduced and thus the amount of light converted to heat is reduced. Secondly, the shaded portions of a collector will lose some of the heat collected by the unshaded portions to the cooler surrounding air. Since shadows affect solar collectors so dramatically, it is important to determine the magnitude and duration of shadows which may be cast upon a proposed collector. *Site Planning* (1) contains a technique for drawing "shadow patterns" which can be utilized to assess the potential impact of a shadow upon a collector. A shadow pattern is the "composite shape of a shadow cast by an object over a given period of time" (Reference 1, pg. 22) Since the sun is lower in the sky during the winter months, winter shadow patterns are longer than summer patterns and hence are more useful in planning for solar access.

The first step in assessing the effect of shadows on solar access is to calculate the shadow patterns for objects south of a proposed collector *both on and off the actual site*. If this analysis shows that unwanted shadows are present, various alternatives will have to be considered. Detached collectors are one possibility; removal of the shadow-casting object is another - although this does get complicated if the object is located offsite. Trees and manmade objects are not the only sources of shadows; hills and mountains can also cause shading. For example, if one proposes to place a collector just to the east of a large hill, the collector may be shaded early in the afternoon.

Microclimate: Each Plot of Land is Different

Some sites are warmer in winter and cooler in summer than others close by. This in turn affects a building's heating and cooling requirements and ultimately the necessary size and efficiency of solar collectors. It is important to realize that two plots of land that have the same topography, wind flow and location of trees and shrubs may not have the same solar collector requirements. For example, a site near a large body of water or one at the foot of a rise located in the direction of prevailing winds may be warmer than a nearby unprotected site. The better the weather-proofing of a house, the less important microclimate is in solar design.

Trees and Landscaping

In order to protect solar access fully, some method must be available to control the shading caused by other buildings and vegetation, especially trees. Buildings which are constant in shape are discussed in an accompanying Bulletin, #244 (2), but unlike buildings, trees and shrubs change shape and size with time. This occurs both on a seasonal basis with deciduous trees, and year to year as trees grow. Cutting back vegetation may seem like a radical and environmentally unsound idea, but all communities do it. For instance, vegetation is commonly not allowed to block the view of an intersection so trees are set back from highway shoulders. Public utilities trim branches and occasionally remove trees along rights-of-way.

Perhaps one of the most difficult tradeoffs involved in developing a new site for solar access involves the preservation of existing trees. Often there is no way to avoid taking down at least some of these trees to provide access to south walls and rooftops. Occasionally, local regulations will require preservation of these trees. The developer is then faced with convincing tree lovers that an exception should be made. *Site Planning* (1) states that existing trees on a site force a developer planning for solar energy use to ask and answer the following questions:

1) How heavily forested is this site and what tree species are present?

2) Which trees must come down to allow home construction?

3) Will the preserved trees let in enough light for passive solar heating in winter or for solar collectors?

4) If not, can some trees be just trimmed or topped, or will additional trees have to come down to preserve solar access?

Ultimately, it comes down to an intelligent balance between solar access on one side and the aesthetics, summer cooling, and wind shelter provided by a canopy of trees on the other. Attention must be given to the species of trees present in order to determine their shading potential, their seasonal changes, their ultimate heights, and their estimated lifetime. For instance, a mature oak may well outlast the house, while a mature box elder may not be worth trying to preserve. A builder, given enough flexibility, may be able to place the house to that it gets sufficient sunshine without uprooting valuable trees.

New vegetation is of course easier to deal with. Species should be selected for height at maturity, spread of the canopy, growth rate, duration of the leaf season, and density of the twigs and branches. Large trees should not be planted within the 45- or 50-degree wedge of sky space to the south of a collector, but they can and should be planted to the north of buildings or collectors. Dense evergreen foundation plantings may be preferable on the north side while deciduous shrubs and vines are preferable on the sunny south side.

References

(1) *Site Planning for Solar Access - A Guidebook for Residential Developers and Site Planners*. U.S. Department of Housing and Urban Development, Contract Number H-2573 (may be available free from National Solar Heating and Cooling Information Dissemination Center, (800) 523-2929)

(2) Ford, Mary Elizabeth, *"Making Solar Heating a Reality: Planning Considerations and Town Codes."* RCSI Bulletin #244, November 1980