MASTER

FUNDAMENTALS OF SOLAR ACCESS

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Fundamentals Of **SOLAR ACCESS**

Mike Levin

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THE FUNDAMENTALS OF SOLAR ACCESS*

by MIKE LEVIN

In the past few years, there has been a rapid acceleration of programs to reduce institutional and economic barriers to accommodate the increasing use of solar energy. Yet one of the major issues which still remains unresolved is the protection of access to sunlight.

Solar access refers to the availability of sunlight to solar collectors. Both active and passive solar systems require exposure to the sun. While solar access is simple to understand, the required conditions are not always as simply met. Nowhere in the continental U.S., at any time, is the sun directly overhead. The path of the sun in the sky means that a solar system is dependent upon sunlight which may travel over adjacent properties to reach it (Figure A). The placement and configuration of structures and vegetation on these nearby properties can become very important to the solar user. Depending upon their placement, they can block the sun or let it shine through to the system. While a property owner can tailor his own land uses to avoid casting shadows on his solar system, he does not normally control his neighbor's use of the land.

*Based on a slide presentation delivered on three occasions: "Symposium on Legal Issues in Building Codes Administration" sponsored by the National Conference of States on Building Codes and Standards on May 7, 1981; "Solar Symposium for Local Officials" sponsored by the National League of Cities, the National Association of County Officials, and the U.S. Conference of Mayors on May 5, 1981; and "Alabama Solar Access Conference" sponsored by Alabama Department of Energy on April 1, 1981. The purpose of the slide presentation is to provide local government officials with a basic understanding of solar access and to offer a sampling of options available to protect and provide for solar access.

Unfortunately, building permits are granted every day for structures that shade potentially excellent locations for solar collectors. Subdivisions are approved which orient streets and lots so that houses cannot take advantage of the sun's energy. Cities proudly plant trees that may, in effect, leave their citizens in the cold by blocking the sun. Unless state and local governments plan now, it could be more difficult for solar development to take place.

Solar Geometry

To further understand solar access and to appreciate the role that state and local governments can play in the protection of solar access, it is helpful to review the fundamentals of solar geometry.

In designing and locating solar systems, it is necessary to know something about the sun's path in the sky. Of course, it is really the earth rotating on its axis once a day in orbit around the sun that gives the impression of the sun's movement. These movements and the effect of latitude and topography determine how much sunlight falls on a particular spot on earth and how easy or difficult it is to protect access to that sunlight.

The sun's position in the sky is defined by two angles. The height above the horizon is called altitude and can range from zero degrees (at the horizon) to ninety degrees (directly overhead). The position of the sun from east to west is called its azimuth. Solar azimuth is measured from true south, with a negative value to the east and positive value to the west.

To find the altitude angle, face the sun and point a finger at it. The angle formed by your extended arm and a horizontal line is the altitude angle. For azimuth angles, point due south with one hand and point towards the sun with the other. The angle between your arms is the azimuth angle.

Because of the tilt of the earth's axis, the sun's altitude is higher during the summer months and lower in the winter (Figure B). Thus, access to the sun is more easily obstructed by buildings and vegetation in the winter.

WINTER & SUMMER SUN PATHS

FIGURE B

Sun angles change with latitude because the sun strikes different spots on the globe at different angles (Figure C). The farther north you go, the lower the angle of the sun.

FIGURE C

The Intensity of Sunlight Decreases with Latitude and Season Because of the Tilt of the Earth

At the lower solar altitudes in the north, the same number of sun rays are falling on a wider area. Just as a flashlight beam is dispersed if it is aimed at a wall from a position parallel to it (Figure D), the greatest concentration of the beam/or sunrays will be obtained when the light is aimed at right angles to the wall. The most important implication of latitude then, is that at northern latitudes the sun is lower in the sky, making it harder to protect collectors from shading.

SHADOW PATTERNS

FIGURE D

Topography

Topography also affects the amount and angle of solar radiation that reaches the ground. Since changes in topography can occur across short distances, it can present a challenge in planning for solar access. South-facing slopes provide the best opportunities for good solar access. North-facing slopes, on the other hand, are the poorest because solar access can be totally blocked out (Figure E).

FIGURE E

The altitude and azimuth of the sun also define the amount of sky that a solar collector must "see" if it is to perform effectively (Figure F). It is this "skyspace" that must be protected from trees, buildings, or other obstructions. Nearly 85 percent of the sun's energy reaching the earth falls roughly between 9:00 a.m. and 3:00 p.m. When converting these time limits to azimuth angles, the time results in an east to west skyspace boundary of forty-five degrees either side of due south. The upper and lower boundaries of the skyspace are determined by the altitude of the sun on December 21 and June 21 respectively. An important implication of the skyspace boundaries is that it is not necessary that solar collectors be guaranteed access to the sun from sunrise to sunset.

SOLAR SKYSPACE

FIGURE F

While topography changes can affect solar access, changes in topography do not change the forty-five degree skyspace (Figure G). The same skyspace is needed on a north or south facing slope. What does change, then, is the distance between the ground and lower edge of the skyspace which will affect how close or how tall adjacent buildings or trees can be.

TOPOGRAPHY & SKYSPACE

FIGURE G

DISTANCE A IS GREATER THAN B . AND B IS GREATER THAN C.

There are four basic levels of solar access: roof, wall, south lot or ground, and detached (Figure H). Detached or roof-mounted collectors usually pose the fewest solar access problems because they are placed at a high level in the sky. Ground mounted collectors are the most difficult to protect, since they are lower and the most susceptible to shading.

LEVELS OF SOLAR ACCESS

FIGURE H

Orientation

Solar geometry dictates that the best orientation for buildings is with the long axis oriented east to west. This allows for the longest sections of the wall to face south and have the greatest exposure to the sun.

One of the best ways to assure proper building orientation is simply to run streets from east to west. In designing a road system for a new residential development, solar access strategies can be incorporated into the site plan. A proposed north-south street orientation can be changed to an east/west orientation and still provide densities equal to conventional subdivision layout (Figure 1). In fact, recent studies have demonstrated that builders need not lose profits by orienting lots for solar access.

FIGURE 1

Granted, it is not always possible to orient streets from east to west. Topography may demand that streets follow elevation contours to minimize grading costs and to prevent erosion and run-off problems. However, collectors and buildings still can receive adequate sunlight even if not oriented directly due south (Figure J). A good orientation can still be achieved within 22-1/2 degrees variation from east to west of due south, and an acceptable orientation can be achieved within a 45 degree variance.

FIGURE J

LONG AXIS ORIENTATION FOR DETACHED HOUSING

45° VARIATION FROM IDEAL EAST/WEST ORIENTATION IS ACCEPTABLE, AND A MAXIMUM 22.5° VARIATION IS BETTER, TO ASSURE PROPER WINTER HEAT GAIN AND SUMMER SHADE CONTROL.

Solar access planning does not stop with the designing of east-west streets. Developments can have several housing types. In that situation, taller buildings should be placed on the south side of the street and shorter buildings on the north side to reduce shading (Figure K).

FIGURE K

STREETS AS SHADOW BUFFERS

In evaluating new developments, local governments can require that developers submit one or more variations of a site master plan to aid in planning for solar access (Figure L). A building shadow plan and a tree shadow plan are useful tools for evaluating a design for solar access strategies.

FIGURE L

SITE MASTER PLAN

NORTH

BUILDING SHADOW PLAN

TREE SHADOW PLAN

Trees and Vegetation

Trees and vegetation are also vital considerations for solar access. But trees, unlike houses and streets, change dramatically over time. If planted wisely, trees can provide helpful summer shading without blocking the collector. The type of tree is also critical and should receive careful study and consideration. The city of Davis, California, studied the percentage of sunlight penetration for 10 different species of trees and found that even leafless trees can block sunlight. Bare branches and twigs can sometimes shade anywhere between 20 and 85 percent of the available sunlight.

Public tree controls can also have an immediate effect on solar access in most communities. Shorter trees on the north side of the street and taller trees on the south side can improve solar access (Figure M). The best opportunity for tree planning clearly occurs in new developments. Established areas can be assured of solar access through controlling tree growth to avoid shading solar collectors.

FIGURE M

Design Options

Local governments can provide for solar access protection by merely being more flexible when approving building plans. For example, with regard to setback requirements, the traditional building pads on north/south, east/west, and intercardinal streets require only simple changes in direction to provide good solar orientation (Figure N).

FIGURE N

Using parking lots as solar buffers can also protect solar access. For example, a simple reversal of an apartment structure and its parking lot can assure continued solar access for houses that would otherwise be shaded (Figure O). This reversal could also result in the cars being hidden from street view, providing greater security and improved aesthetics.

FIGURE O

Another simple design change involves the commonly found tower block highrise design which normally prevents solar access to at least one of its units. A modified version of the tower block, or what is called a cruciform design, can provide solar access to some part of every unit (Figure P).

FIGURE P

CRUCIFORM HIGH-RISE
ORIENTATION TOWER BLOCK HIGH-RISE
ORIENTATION

#1 lacks access

All have Southeast-Southwest Access

Another design option for buildings already shaded by trees or structures is to have a common collector bank in an open space (Figure Q).

FIGURE Q

COMMON COLLECTOR BANK

Height limitations should also be considered by local government officials. Traditional height and setback requirements usually specify one height that is allowable over the buildable area of the lot. These requirements result in a box called a building envelope (as defined by setback, lot lines, and maximum height) within which a building can be constructed (Figure R). Changing the traditional height and setback requirements to improve solar access will also change the shape of this building envelope (Figure S). The new shape is called the solar envelope or bulk plane, and is just a graduated version of height and setback of the conventional building envelope. As setback requirements increase, the height of a building can increase without shading another lot. All buildings and vegetation must be under the bulk plane to avoid shading the adjacent building.

FIGURE R

FIGURE S

Legal Questions

Changes in attitudes and procedures among community officials can have a strong impact on the achievement of good solar access policies; however, the legal protection of sun rights through legislation is essential if people are to be encouraged to invest in solar systems.

More than twenty states have already enacted legislation allowing privately negotiated solar easements and establishing recording requirements. Approximately 14 states have enabling legislation allowing cities or counties to enact rules protecting a person's right to the sun.

The protection of solar access through the granting of sunrights has a long history. When the Greeks and Romans made extensive use of passive solar structures, law forbade construction that blocked an existing structure's sunlight. In English law, the "Doctrine of Ancient Lights" has for centuries recognized a land owner's right to light coming in over neighboring lands, provided it has been received unobstructed for a certain length of time. Currently, this period is 27 years. In Japan, sun rights have also long been recognized. A 1972 Supreme Court case in that country reaffirmed solar access as a protectable interest and awarded damages to a homeowner whose light had been blocked by an addition to a neighboring residence.

In this country, however, the right to light has not fared as well. Courts in the United States have repeatedly denied the existence of a common-law right to light, consistent with public policy that has traditionally favored the full development of property. In recent years, however, there has been a resurgence of interest in the sunrights concept. The real essence of the solar access issue was tried recently in a Wisconsin circuit court case - Prah v. Maretti. This case was illustrative of the real solar access issue which must be faced in all states. The issue was as follows:

Does a homeowner who installs a solar system which depends on the energy from the sun for its efficient operation have the right to enjoin an adjacent neighbor who was constructing a residence on his own land which, by reason of its location, would interfere with the efficiency of the installed solar system?

Prah installed a solar heating system on his home (Figure T). At the time, the property to the south of his home was vacant. Maretti came along and began construction of his residence on the south lot which, because of grade elevation and proximity to Prah's land, caused a shadow to be cast on his solar collectors in the cold winter months (Figure U). Prah contended that if Maretti had placed his house an additional 5 feet south of the property line, there would not have been any shading of his solar system (Figure V). Prah also contended he had a right to have an unobstructed path from his solar collectors to the sun.

FIGURE T

FIGURE U

FIGURE V

Of significance is Prah's contention that he acquired his solar rights by "prior appropriation," since he had installed his system before Maretti built his house and had notified his neighbor of the nature of his heating system and its requirements. The court ruled that: "For the court to adjudge that Maretti must move his house 5 feet to the south, would be a deprivation of his property without just compensation."

Only one state, New Mexico, has enacted legislation declaring that the right to use sunlight is a property right. So, in the absence of a similar "prior appropriation" statute in Wisconsin, the court ruled against Prah when it concluded that a decision for the plaintiff Prah, "would be an intrusion of judicial egoism over legislative passivity." The Wisconsin court decision points out the important impact that the protection of property rights has on solar access.

Conclusion

What can government officials do to help citizens who want existing solar energy systems protected or who want the option to use one in the future? For the protection of residents today, it appears that the most certain way to provide for solar access is to have a solar easement. Easements protect homeowners by assuring that they will have access to the sun for efficient operation of a solar system. Easements provide sunshine rights to a particular property owner so that neighboring property owners will not build structures or plant vegetation that would shade their neighbor's system. State and local governments can help by making these easements easy to obtain.

A comprehensive approach to solar access must consider development, zoning, and building code standards, as well as easements and covenants to provide for access. The bottom line is that state and local officials have a major role to play but must work with other key groups such as developers, contractors, and architects to address the solar access issue.

ACKNOWLEDGEMENTS

The following publications were drawn upon for the preparation of this presentation. Some of the illustrations were taken from publications of the National Solar Heating and Cooling Information Center.

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