Appendices

Appendix A:
Glossary

Active (or Indirect) Solar Systems—A system whose collector and thermal storage components are separated and which requires a pump or fan to circulate the solar heated fluid between them. The location of active collectors is flexible, rooftops being a common choice.

Altitude Angle—One of two angles used to specify the sun's position at a given time; altitude is the angle of the sun above the horizontal. (See also "azimuth angle;" "profile angle.")

Angle of Incidence—The angle at which direct sunlight strikes a surface. The angle of incidence affects the amount of energy absorbed by a solar collector. Sunlight with an incident angle close to 90° (perpendicular to the surface) tends to be absorbed or transmitted while sunlight at lower angles tends to be reflected.

Azimuth Angle—One of two solar angles used to specify the sun's position at a given time; azimuth is the angle between south and the point on the horizon directly below the sun (Anderson, 1976). South is 0° and angles to the east and west are described as 0°-180°E or 0°-180°W. (See also "altitude angle;" "profile angle.")

Btu or British Thermal Unit—A measure of energy. One Btu of energy will heat one pound of water 1°F.

Building Orientation—The relationship of a building to south. A building's orientation is specified by the direction its longest walls face. The orientation of building walls, especially those with windows, is a major influence on the building's heat gain and heat loss.

CC & R's (Codes, Covenants, and Restrictions)—A resident's ownership in a development and his legal rights and remedies as a member of the homeowners association are controlled by these governing instruments. A form of deed restriction, CC and R's limit activity (such as shading collectors) on the specified property.

Cold Air Drainage—A low spot or channel in the landscape which tends to collect cold night air. These places often remain cooler than adjacent areas for a significant portion of the day.

Cold Night Sky—The low effective temperature of the cold night sky provides natural cooling. A body outdoors will radiate heat to the cold night sky. This process is used by radiative natural cooling systems such as roof ponds.

Collector—Any device or area which uses the sun's energy to heat, cool or light a living space, heat domestic water or otherwise provide benefits to its user. This broad definition includes not only familiar space and domestic water heating system collectors, but also collectors for space cooling, auxiliary reflective surfaces and outdoor areas such as patios, vegetable gardens, clothes lines and swimming pools which benefit from solar access.

Conduction—The transmission of energy (heat) by the medium itself without movement of the medium. For example, heat is rapidly lost through glass by conduction; the glass serving as a conductor in the heat transfer. (See also "convection" and "radiation.")

Convection—The transfer of heat by the natural circulation of a medium due to differences in temperature and density. Air, for example, rises upon heating with cooler air flowing in below to take its place. (See "thermosiphon," "conduction" and "radiation.")

Cooling Degree Day (CDD)—The number of degrees that the average daily temperature is above 65°F. For example, a day with an average temperature of 75° will have 10 cooling degree days. The concept of Cooling Degree Days was developed to indicate energy use for cooling. Typically the cumulative annual value is given. (See also "heating degree day.")

Cool North Sky—The area of north sky with relatively low temperature on clear days. Heat can be dissipated during the day from a surface shaded from the sun and facing north. Surfaces radiating to the sky in a direction opposite to and at a right angle to the sun will cool because the sky radiates at an effective temperature which is lower than air temperature. The cool north sky can provide effective cooling for systems using shaded roof ponds.

Design Wetbulb Temperatures—Wetbulb temperatures are used to measure the amount of humidity in the air. The lower the humidity the greater the difference between normal dry bulb and wet bulb values. The design wet bulb temperature is the average of those temperatures reached either 1% or 2½% of the hours between June and September. The design wetball temperature is used in designing cooling systems.

Diffuse Sunlight—Sunlight that reaches the earth after being reflected off atmospheric particles and molecules. On a cloudy day diffuse light may account for all the sunlight received at the earth's surface. Diffuse sunlight comes along no set path. It generally comes from the entire sky with the majority coming from the area of the sky near the sun.

Direct Solar Systems—See "passive solar systems."

Direct Sunlight—Sunlight that comes straight from the sun. Skyview angles and most solar planning guidelines are based on direct sunlight.

Earth Sheltering—The concept of utilizing relatively stable earth temperatures to moderate the heating and cooling load on a building. Heat flow in and out of a building is in direct proportion to the interior-exterior temperature difference which is usually quite favorable for underground or bermed structures. Since earth is a poor insulator, earth sheltered structures need insulation between the earth and their interior.

Easement—A form of private agreement with potential to protect solar access. Easements are interests in property which can be bought and sold like property itself. A common example is the utility easement which allows utility companies to enter private property to maintain power lines.

Evaporative Cooling—Cooling provided by the evaporation of water. When water changes phase from liquid to vapor it absorbs a considerable amount of energy which cools both the remaining liquid water and the surrounding air. Most systems utilizing this principle ("swamp coolers", and some types of roof ponds) require shading devices.

Evapotranspiration—See "Transpiration."

Flag Lot—A lot in a housing subdivision which has a shape somewhat resembling a flag and flag pole. This configuration allows an otherwise remote parcel to have access to a roadway.

Heading—A horticultural term describing a type of pruning cut. It refers to cutting back to a lateral bud, small lateral branch or stub. Vigorous new growth often occurs below the cut.

Hot Season—Those months when space cooling is needed. Tables presenting the hot season months for various parts of the state are given in the Climate Regions Chapter.

Indirect Solar Systems—See Active Solar Systems.

Leaf-Fall Date—That date when most of the leaves of a deciduous plant have fallen off and the plant is in a bare branch state. At this point, deciduous trees allow the maximum sunlight penetration.

Leaf-Out Date—That date when the majority of leaves on a deciduous plant have budded and emerged and give a significant amount of shading.

Lot Coverage—The portion of a lot's surface area that is covered by buildings; usually given as a percentage.

Microclimate—The climate of a specific site or portion of a site. Microclimates result from the overall regional climate as affected by local site conditions such as ground slope and orientation, topographic features, elevation, vegetation, winds, water bodies, ground surface material and buildings. These microclimatic influences affect both heating and cooling requirements of housing as well as their solar access.

Mixed Use Development (MXD)—See planned unit development.

Movable Insulation—Types of thermal insulation which can be moved across windows or skylights to control heat transfer both summer and winter. Examples include insulated shutters and draperies.

Natural Cooling—Space cooling alternatives to energy-consuming central air conditioning systems. The five principal means of natural cooling are: shading, ventilation, earth sheltering, radiation and evaporation.

North Projection—The length of an object's shadow pattern measured along the north/south axis. The north projection of an object's shadow is useful in density calculations where minimum building spacing is to be determined while retaining solar access.

Orientation—Position with respect to true compass points. See also "Building Orientation."

Passive (or Direct) Solar Systems—A system whose collector and thermal storage components are integrated, requiring no transfer device for solar heated fluid. Passive systems tend to have less hardware than active systems; and they are usually built as essential parts of the building.

Planned Unit Development (PUD)—A development planned as a whole where traditional subdivision regulations such as type of housing, height limitations, setbacks, densities and minimum lot sizes are waived in order to allow greater design flexibility and increased amenities. This kind of development usually makes solar access planning easier. Also known as a planned development or a mixed use development (MUD).

Profile Angle—The angle formed by projecting the sun's angles onto a specified building section; typically in solar planning the north/south axis.

Radiation—As used here, radiation refers to either 1) the propogation of energy through space or through a medium in the form of waves; or 2) the energy itself as in solar radiation (light). Heat and light (the two forms of radiant energy discussed here) have different wavelengths and therefore react differently to a given material. Glass, for example, transmits light far more easily than heat, but glass transmits heat far more rapidly than various insulating materials.

Radiative Cooling—Cooling provided by warm surfaces radiating excess heat to cool surfaces. Water bodies (roof ponds) and massive construction materials (concrete and stone) have the ability to absorb heat from interior spaces during daytime to radiate it away at night. (See also "Cold Night Sky" and "Cool North Sky.")

Restrictive Covenants—The most common form of private agreement which can be used to protect solar access. A restrictive covenant is a contract between two or more people, which involves mutual promises of reciprocal benefits and burdens among the contracting landowners.

Retrofit—A structure (or possibly an outdoor space) which has been remodeled to reduce its energy use.

Shading Coefficient—The shading coefficient is the ratio of a shaded window relative to an unshaded window. For example, a simple horizontal overhang over south glass gives a shading coefficient of 0.25. The lower the ratio; the less heat gain through the window. (After Olgyay, 1963).

Skyview—The extent of unobstructed sky that a solar collector must "see" in order to perform effectively. Protecting solar access simply means locating objects such as buildings and trees where they will not shade a collector's skyview. Skyview is specified by using latitude-dependent solar angles which give the sun's position at critical times. Skyview requirements vary with latitude and the use pattern of the collector.

Skyview Shift—Collecting sunlight where and when it is available if the prime solar access period is blocked by shadows. For example, if the optimum skyview is between 10 am and 2 pm but shadows limit collection after 1 pm, then sunlight can be gathered (skyview shifted) before 10 am.

Solar Access—Allowing sunlight to strike a solar collector. Solar access requires locating obstructions such as buildings and trees where their shadows will not fall on a collector during critical periods of its operation. The concept of skyview defines that portion of the sky which must remain unobstructed and specifies critical angles for use in solar planning.

Solar Angles—Angles used to specify the sun's position at a given time. (See also "Altitude Angle" and "Azimuth Angle.")

Solar Control—Limiting sunlight during the hot season. Architectural shading devices and shading by vegetation are the two principal methods.

Solar Envelope—A container to regulate development within limits derived from the sun's relative motion. Development within this container will not shade surrounding structures during critical periods of the day. (Knowles and Berry, 1980)

Solar Rights—Legal guarantee of solar access as specified by private legal agreements or by law. California's Solar Shade Control Act (AB 2321) is an example.

Solar Tempered—A building with a long wall, major windows oriented to the south and windows shaded during the hot season. This maximizes beneficial sunlight warming the building in winter and minimizes unwanted heat gain in summer. Solar tempering can be used to advantage in almost all California climate regions.

Solar Time—Time measured by the actual location of the sun as opposed to the averaged time zone method. For example, solar noon occurs when the sun aligns with the north/south axis.

Stack Effect—The natural convective air flow (warm air rising) which is enhanced by tall architectural spaces.

Sun Trap—Interior and exterior spaces that capture solar energy and tend to become warm. Such spaces are usually protected from heat dissipating winds and are comfortable on otherwise cool days.

Surface to Volume Ratio—A measure of a building's exposure to potentially adverse outdoor conditions. The lower the ratio of a building's surface area to its enclosed volume, the more thermally efficient it will be and the less load will be put on its solar energy system. This ratio is especially valuable in weighing alternative building forms.

Thermal Mass—Any material used to store the sun's heat and/or the night's coolness. Water, concrete and rock are common choices for thermal mass. In winter thermal mass stores solar energy collected during the day and releases it during sunless periods (nights or cloudy days). In summer thermal mass absorbs excess daytime heat and allows it to be discharged to the outdoors at night by ventilating the building.

Thermosiphon—A method of circulating a fluid where the warmer, less dense portion rises above the cooler. This method can be used in place of pumps to transfer solar heated water or air from collectors to storage or use areas.

Thinning—A horticultural term referring to a pruning method where branches are shortened or eliminated to increase light penetration to the middle of the tree. The evenly distributed resultant growth gives an open, structurally sound tree.

Tilt—The angle of a surface, usually a solar collector, as measured from the horizontal. Different tilts result in variations in the amount of sunlight received. Tilt angles are primarily based on collector use period and latitude.

Transpiration or Evapotranspiration-The release and evaporation of moisture through plant cells. Transpiration, as a form of evaporation, is a cooling process that affects the microclimate around plants.

Use Pattern (or Use Period)—The use pattern of a solar system refers to the time when the system is needed. The *daily use pattern* for residences is both day and night, while systems in offices and schools may be used only during daytime hours. The *yearly use pattern* is related to the function of the solar system; for example, space heating is used only during the cold season, while domestic water heating is used all year. The use pattern determines the skyview requirements of solar system.

Appendix B:
Comparison of the Thermal Performance of Conventional, Solar Tempered and Passive Solar Homes

Note: Each of the six *Climate Region* sections compares the performance of the "conventional house," a "solar tempered house," and a "solar house." The "conventional house" specifications appear in the chart at the beginning of this appendix. The figures in the *Climate Region* sections refer to this house with the majority of its windows oriented northwest. The "solar tempered" house reorients the "standard house" south, incorporates the conservation measures mentioned above and uses a summer shading coefficient of 0.2. The "solar house" adds the equivalent of 12,000 pounds of water and 150 square feet of south facing glass to the "solar tempered" house and provides movable insulation on 75 percent of its windows.

Modifying the Conventional House for Energy Conservation

Orientation

The first step in modifying the study's "conventional house" was to rotate it in order to simulate performance changes at different orientations of its major window areas. Not surprisingly, a south orientation of the major windows on the front elevation proved to be best, except in *Desert Region* climates where *unshaded* south glass was less beneficial than a north orientation.

Conservation Measures

Using the results of a south orientation, the following additional measures were evaluated individually and cumulatively. The cumulative performance appears under the "total" heading in the tables at the end of this appendix.

Roof insulation—increase to R-30
Double pane—all windows
Insulate Slab—add 1 inch rigid insulation at slab edge to bottom of footing
Reduce Infiltration—reduce to 0.75 air changes per hour
Ventilation—increase summer night ventilation to 9.0 air changes per hour
Roof color—light

Shading

Using the cumulative design modifications given above, window shading in summer was next added by using a shading coefficient as a measure. (The shading coefficient is the ratio of solar heat gain of the shaded window relative to an unshaded window; the lower the ratio the less heat entering the window). Coefficients of 0.8 to 0.2 were evaluated.

Shutters

The effects of any type of movable window insulation were simulated on the house having 12,000 pounds of mass and 150 square feet of additional south facing window area. An "R" value of 5 was used for the window insulation. Shuttering varying percentages of the windows—from 25 percent to 100 percent—was simulated.

Mass

Using the most well shaded house as a base, the effects of adding both thermal mass (in any form) and south facing windows were analyzed next. Mass was added in increments of 3000 pounds of water, and south windows in units of 50 square feet. The first increment added only 3000 pounds of water without increasing window area. Subsequent increments add 3000 pounds of water plus the 50 square feet of window area.

Mass		South Facing Window Area
3,000 lbs.		
6,000 lbs.	+	50 S.F.
9,000 lbs.	+	100 S.F.
12,000 lbs.	+	150 S.F.

Results of the above work were presented in a number of ways. All changes were analyzed into their effect on the house's heating and cooling performance and reported as follows:

Peak Hour– describes maximum likely loads for sizing heating and air conditioning systems. Values are given in thousands of Btu's per hour (KBTU/Hr).

Annual– a summary of the yearly performance is given in units of energy and costs. Energy units are millions of Btu's (MBTU) and costs are given in dollars. Heating is done with natural gas costing $0.50 per therm (a therm equals 100,000 Btu). Cooling is done by electricity costing $0.050 per kilowatt hours, assuming an energy efficiency ratio of 7 for the air conditioning system. The costs assumed are likely to increase. The California Energy Commission's 1980 Biennial Report estimates an 87 percent increase in natural gas costs from 1980 to 1985. Electrical rates are expected to increase 210 percent between 1979 and 1985.

The "conventional house" specifications for this study appear in the chart below. The house meets California's State Energy Code Requirements (Title 24) and approximates typical new development housing being built throughout California.

—Floor area	1342 S.F.
—Window distribution	
Front elevation	119 S.F.
Rear elevation	50
Right elevation	21
Left elevation	33
—Window Type	Single Glazing
—Insulation	
Roof	R19
Walls	R11
Slab perimeter	None
—Infiltration rate	1 air change per hour (weatherstripped)
—Ventilation	4.5 air changes per hour (based on all windows open for a house not particularly designed for cross ventilation)
—Roof color	Dark (asphalt shingle)
—Exterior window shading	None
—Equivalent thermal mass	Sheet rock only (floor slab carpeted)
—Movable window insulation	None

Fog Belt	**Peak Hour**		**Annual**			
Performance Comparison of Various "Standard House" Modifications	Heating (KBtu/hr)	Cooling (KBtu/hr)	Heating (MBtu/hr)	$	Cooling (MBtu/hr)	$
Orientation						
South	37.8	19.8	51.0	$425	—	—
SW/SE	37.8	27.1	51.8	432	—	—
W/E	37.8	31.6	52.9	441	—	—
NW/NE	37.8	21.6	58.6	488	—	—
North	37.8	14.9	55.2	460	—	—
Conservation						
Roof Insulation	36.1	19.9	47.1	392	—	—
Double Pane	35.3	20.0	45.6	380	—	—
Slab Insulate	34.9	19.8	44.2	368	—	—
Infiltration	33.4	20.4	40.5	337	—	—
Ventilation	36.7	9.5	50.9	424	—	—
Roof color	37.7	18.9	50.9	424	—	—
Total	**25.4**	**9.85**	**24.6**	**$205**	**—**	**$—**
Shading						
Coefficient = 0.8	25.4	—	24.6	205	—	—
Coefficient = 0.6	25.4	—	24.6	205	—	—
Coefficient = 0.4	25.4	—	24.6	205	—	—
Coefficient = 0.2	25.4	—	24.6	205	—	—
Mass						
3,000 lbs.	24.5	—	15.0	125	—	—
6,000 lbs. + 50 S.F.	23.6	—	8.5	71	—	—
9,000 lbs. + 100 S.F.	22.6	—	3.9	32	—	—
12,000 lbs. + 150 S.F.	21.7	—	1.8	15	—	—
Shutters						
25% of Windows	21.1	—	1.5	12	—	—
50% of Windows	20.4	—	1.1	9	—	—
75% of Windows	19.8	—	0.8	7	—	—
100% of Windows	19.1	—	0.5	4	—	—

Mild Marine	Peak Hour		Annual			
Performance Comparison of Various "Standard House" Modifications	Heating (KBtu/hr)	Cooling (KBtu/hr)	Heating (MBtu/hr)	$	Cooling (MBtu/hr)	$
Orientation						
South	34.9	32.5	14.9	$124	1.6	$11
SW/SE	34.9	40.0	15.3	127	1.9	14
W/E	34.9	46.0	15.4	128	2.2	16
NW/NE	34.9	37.3	17.0	142	1.8	13
North	34.9	29.2	16.0	142	1.4	10
Conservation						
Roof Insulation	33.6	31.9	13.6	113	1.5	11
Double Pane	30.3	32.2	10.5	87	1.5	11
Slab Insulate	32.7	32.5	12.7	106	1.6	11
Infiltration	31.4	32.1	11.4	95	1.5	11
Ventilation	34.6	30.9	14.9	124	1.5	11
Roof color	34.9	31.6	14.9	124	1.5	11
Total	**23.0**	**29.2**	**4.5**	**$ 37**	**1.4**	**$10**
Shading						
Coefficient = 0.8	23.0	20.2	4.5	37	0.9	6
Coefficient = 0.6	23.0	13.1	4.5	37	0.6	4
Coefficient = 0.4	23.0	8.1	4.5	37	0.3	2
Coefficient = 0.2	23.0	5.1	4.5	37	0.2	1
Mass						
3,000 lbs.	22.7	4.8	1.9	16	0.2	1
6,000 lbs. + 50 S.F.	22.5	4.6	0.8	7	0.2	1
9,000 lbs. + 100 S.F.	22.2	4.4	0.1	1	0.2	1
12,000 lbs. + 150 S.F.	21.9	4.1	—	—	0.1	1
Shutters						
25% of Windows	21.1	2.7	—	—	0.1	1
50% of Windows	20.4	1.2	—	—	—	—
75% of Windows	19.6	—	—			
100% of Windows	18.8					

Mild Interior Performance Comparison of Various "Standard House" Modifications	Peak Hour Heating (KBtu/hr)	Peak Hour Cooling (KBtu/hr)	Annual Heating (MBtu/hr)	Annual Heating $	Annual Cooling (MBtu/hr)	Annual Cooling $
Orientation						
South	48.7	40.0	37.1	$309	33.4	$239
SW/SE	48.7	47.4	37.6	313	39.6	283
W/E	48.7	52.6	38.2	318	44.0	314
NW/NE	48.7	43.1	41.2	343	35.9	256
North	48.7	35.8	39.3	327	29.8	213
Conservation						
Roof Insulation	46.9	39.3	35.0	292	32.8	234
Double Pane	42.3	38.6	29.8	248	32.2	230
Slab Insulate	45.6	40.0	33.5	279	33.4	239
Infiltration	43.8	38.3	31.4	262	32.0	229
Ventilation	48.1	37.0	37.1	309	30.6	219
Roof color	48.7	39.2	37.1	309	32.7	234
Total	**31.8**	**32.6**	**18.4**	**$153**	**26.9**	**$192**
Shading						
Coefficient = 0.8	31.8	23.1	18.4	153	18.9	135
Coefficient = 0.6	31.8	15.7	18.4	153	12.6	90
Coefficient = 0.4	31.8	10.4	18.4	153	8.2	59
Coefficient = 0.2	31.8	7.2	18.4	153	5.5	39
Mass						
3,000 lbs.	31.3	6.7	13.6	113	5.1	36
6,000 lbs. + 50 S.F.	30.7	6.3	9.5	79	4.6	33
9,000 lbs. + 100 S.F.	30.2	5.8	7.2	60	4.2	30
12,000 lbs. + 150 S.F.	29.6	5.4	5.4	45	3.8	27
Shutters						
25% of Windows	28.5	3.8	4.8	40	2.6	18.5
50% of Windows	27.4	2.1	4.2	35	1.4	10
75% of Windows	26.3	0.5	3.5	29	0.3	2
100% of Windows	25.2	—	2.9	24	—	—

Desert Performance Comparison of Various "Standard House" Modifications	**Peak Hour** Heating (KBtu/hr)	Cooling (KBtu/hr)	**Annual** Heating (MBtu/hr)	$	Cooling (MBtu/hr)	$
Orientation						
South	49.2	47.2	10.2	$ 85	115.7	$826
SW/SE	49.2	54.5	10.6	88	133.7	949
W/E	49.2	60.4	10.8	90	148.2	1057
NW/NE	49.2	51.8	11.4	95	127.0	907
North	49.2	43.9	10.9	91	107.6	768
Conservation						
Roof Insulation	47.4	46.0	9.5	79	113.0	807
Double Pane	42.8	45.1	7.6	63	110.5	789
Slab Insulate	46.1	47.2	8.9	74	115.7	826
Infiltration	44.3	44.6	8.2	68	109.4	781
Ventilation	49.1	46.6	10.3	86	114.2	816
Roof color	49.2	46.3	10.3	86	113.5	811
Total	**32.8**	**40.3**	**3.5**	**$ 29**	**98.9**	**$706**
Shading						
Coefficient = 0.8	32.8	31.2	3.5	29	76.4	546
Coefficient = 0.6	32.8	24.0	3.5	29	58.9	421
Coefficient = 0.4	32.8	19.0	3.5	29	46.3	331
Coefficient = 0.2	32.8	15.9	3.5	29	38.8	277
Mass						
3,000 lbs.	32.7	15.8	0.7	6	38.6	276
6,000 lbs. + 50 S.F.	32.6	15.7	—	—	38.4	274
9,000 lbs. + 100 S.F.	32.5	15.6	—	—	38.1	272
12,000 lbs. + 150 S.F.	32.4	15.5	—	—	38.0	271
Shutters						
25% of Windows	31.3	13.8	—	—	33.7	241
50% of Windows	30.2	12.0	—	—	29.4	210
75% of Windows	29.1	10.3	—	—	25.1	179
100% of Windows	28.0	8.5	—	—	20.8	149

Warm Mountain	Peak Hour		Annual			
Performance Comparison of Various "Standard House" Modifications	Heating (KBtu/hr)	Cooling (KBtu/hr)	Heating (MBtu/hr)	$	Cooling (MBtu/hr)	$
Orientation						
South	76.3	30.4	81.2	$677	12.9	$ 92
SW/SE	76.3	37.6	83.6	697	16.1	115
W/E	76.3	41.9	86.9	724	18.0	129
NW/NE	76.3	31.9	92.2	768	13.6	97
North	76.3	25.3	89.1	742	10.6	76
Conservation						
Roof Insulation	73.1	30.1	76.3	636	12.8	91
Double Pane	71.5	29.9	74.8	623	12.7	91
Slab Insulate	70.7	30.4	72.6	605	12.9	92
Infiltration	67.5	29.2	67.9	566	12.4	89
Ventilation	75.1	21.6	81.3	677	8.6	61
Roof color	76.3	29.5	81.3	677	12.5	89
Total	**52.5**	**19.2**	**48.1**	**$401**	**7.6**	**$ 54**
Shading						
Coefficient = 0.8	52.5	9.3	48.1	401	3.2	23
Coefficient = 0.6	52.5	1.5	48.1	401	0.3	2
Coefficient = 0.4	52.5	—	48.1	401	—	—
Coefficient = 0.2	52.5	—	48.1	401	—	—
Mass						
3,000 lbs.	51.4	—	43.4	362	—	—
6,000 lbs. + 50 S.F.	50.3	—	35.9	299	—	—
9,000 lbs. + 100 S.F.	49.2	—	29.5	246	—	—
12,000 lbs. + 150 S.F.	48.0	—	24.1	201	—	—
Shutters						
25% of Windows	46.8	—	22.4	187	—	—
50% of Windows	45.5	—	20.8	173	—	—
75% of Windows	44.2	—	19.2	160	—	—
100% of Windows	42.9	—	17.5	146	—	—

Cold Mountain	**Peak Hour**		**Annual**			
Performance Comparison of Various "Standard House" Modifications	Heating (KBtu/hr)	Cooling (KBtu/hr)	Heating (MBtu/hr)	$	Cooling (MBtu/hr)	$
Orientation						
South	75.5	22.4	96.2	$802	1.0	$ 7
SW/SE	75.5	29.8	99.2	827	1.3	9
W/E	75.5	34.7	101.8	848	1.5	11
NW/NE	75.5	25.0	108.3	902	1.1	8
North	75.5	17.9	104.9	874	0.7	5
Conservation						
Roof Insulation	72.1	22.4	90.3	752	1.0	7
Double Pane	70.4	22.2	88.4	737	1.0	7
Slab Insulate	73.3	22.4	92.5	771	1.0	7
Infiltration	66.3	21.7	80.1	667	0.9	6
Ventilation	74.0	8.9	96.2	802	0.4	3
Roof color	75.5	21.5	96.2	802	0.9	6
Total	**54.2**	**7.4**	**62.8**	**$523**	**0.3**	**$ 2**
Shading						
Coefficient = 0.8	54.2	—	62.8	523	—	—
Coefficient = 0.6	54.2	—	62.8	523	—	—
Coefficient = 0.4	54.2	—	62.8	523	—	—
Coefficient = 0.2	54.2	—	62.8	523	—	—
Mass						
3,000 lbs.	52.9	—	58.1	484	—	—
6,000 lbs. + 50 S.F.	51.6	—	50.6	422	—	—
9,000 lbs. + 100 S.F.	50.3	—	43.7	364	—	—
12,000 lbs. + 150 S.F.	49.0	—	38.0	317	—	—
Shutters						
25% of Windows	47.7	—	36.0	300	—	—
50% of Windows	46.4	—	33.9	282	—	—
75% of Windows	45.0	—	31.9	266	—	—
100% of Windows	43.7	—	29.8	248	—	—

Appendix C:
Solar Angles

The following Solar Angles Tables give the altitude and azimuth angles of the sun at the specified times for the 21st day of each month for each two degree increments of latitude in California.

Solar Angle Table at 32° N. Latitude

Solar Time	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	NOON	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM
January 21													
Altitude	0.	1.	13.	22.	31.	36.	38.	36.	31.	22.	13.	1.	0.
Azimuth	*****	-65.	-56.	-46.	-33.	-18.	0.	18.	33.	46.	56.	65.	*****
February 21													
Altitude	0.	7.	18.	29.	38.	45.	47.	45.	38.	29.	18.	7.	0.
Azimuth	*****	-73.	-64.	-53.	-39.	-21.	0.	21.	39.	53.	64.	73.	*****
March 21													
Altitude	0.	13.	25.	37.	47.	55.	58.	55.	47.	37.	25.	13.	0.
Azimuth	-90.	-82.	-73.	-62.	-47.	-27.	0.	27.	47.	62.	73.	82.	90.
April 21													
Altitude	6.	19.	31.	44.	56.	65.	70.	65.	56.	44.	31.	19.	6.
Azimuth	-100.	-92.	-84.	-74.	-60	-37.	0.	37.	60.	74.	84.	92.	100.
May 21													
Altitude	10.	23.	35.	48.	61.	72.	78.	72.	61.	48.	35.	23.	10.
Azimuth	-107.	-100.	-93.	-85	-73.	-52.	0.	52.	73.	85.	93.	100.	107.
June 21													
Altitude	12.	24.	37.	50.	62.	74.	81.	74.	62.	50.	37.	24.	12.
Azimuth	-110.	-103.	-97.	-89.	-80.	-61.	0.	61.	80.	89.	97.	103.	110
July 21													
Altitude	11.	23.	36.	48.	61.	72.	79.	72.	61.	48.	36.	23.	11.
Azimuth	-108.	-101.	-94	-85.	-74.	-53.	0.	53.	74.	85.	94.	101.	108.
August 21													
Altitude	6.	19.	32.	44.	56.	66.	70.	66.	56.	44.	32.	19.	6.
Azimuth	-100.	-93.	-85.	-75.	-61	-38.	0.	38.	61.	75.	85.	93.	100.
September 21													
Altitude	0.	13.	25.	37.	47.	55.	58.	55.	47.	37.	25.	13.	0.
Azimuth	-90	-82.	-73.	-62.	-47.	-27.	0.	27.	47.	62.	73.	82.	90.
October 21													
Altitude	0.	7.	19.	30.	39.	45.	48.	45.	39.	30.	19.	7.	0.
Azimuth	*****	-73.	-64.	-53.	-39.	-21.	0.	21.	39.	53.	64.	73.	*****
November 21													
Altitude	0.	2.	13.	23.	31.	36.	38.	36.	31.	23.	13.	2.	0.
Azimuth	*****	-65.	-57.	-46.	-33.	-18.	0.	18.	33.	46.	57.	65.	*****
December 21													
Altitude	0.	0.	10.	20.	28.	33.	35.	33.	28.	20.	10.	0.	0.
Azimuth	*****	*****	-54.	-44.	-31.	-16.	0.	16.	31.	44.	54.	*****	*****

Solar Angle Table at 34° N. Latitude

Solar Time	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	NOON	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM
January 21													
Altitude	0.	1.	11.	21.	29.	34.	36.	34.	29.	21.	11.	1.	0.
Azimuth	*****	-65.	-56.	-45.	-32.	-17.	0.	17.	32.	45.	56.	65.	*****
February 21													
Altitude	0.	6.	18.	28.	37.	43.	45.	43.	37.	28.	18.	6.	0.
Azimuth	*****	-73.	-63.	-52.	-38.	-20.	0.	20.	38.	52.	63.	73.	*****
March 21													
Altitude	0.	12.	24.	36.	46.	53.	56.	53.	46.	36.	24.	12.	0.
Azimuth	-90.	-81.	-72.	-61.	-46.	-26.	0.	26.	46.	61.	72.	81.	90.
April 21													
Altitude	6.	19.	31.	43.	55.	64.	68.	64.	55.	43.	31.	19.	6.
Azimuth	-100.	-92.	-83.	-72.	-58.	-35.	0.	35.	58.	72.	83.	92.	100.
May 21													
Altitude	11.	23.	36.	48.	60.	71.	76.	71.	60.	48.	36.	23.	11.
Azimuth	-107.	-99.	-91.	-82.	-70.	-47.	0.	47.	70.	82.	91.	99.	107.
June 21													
Altitude	13.	25.	37.	49.	62.	73.	79.	73.	62.	49.	37.	25.	13.
Azimuth	-110.	-103.	-95.	-87.	-76.	-55.	0.	55.	76.	87.	95.	103.	110.
July 21													
Altitude	11.	23.	36.	48.	60.	71.	77.	71.	60.	48.	36.	23.	11.
Azimuth	-107.	-100.	-92.	-83.	-71.	-49.	0.	49.	71.	83.	92.	100	107.
August 21													
Altitude	7.	19.	32.	44.	55.	64.	68.	64.	55.	44.	32.	19.	7.
Azimuth	-100.	-92.	-83.	-73.	-59.	-36.	0.	36.	59.	73.	83.	92.	100.
September 21													
Altitude	0.	12.	24.	36.	46.	53.	56.	53.	46.	36.	24.	12.	0.
Azimuth	-90.	-81.	-72.	-61.	-46.	-26.	0.	26.	46.	61.	72.	81.	90.
October 21													
Altitude	0.	6.	18.	28.	37.	43.	46.	43.	37.	28.	18.	6.	0.
Azimuth	*****	-73.	-63.	-52.	-38.	-20.	0.	20.	38.	52.	63.	73.	*****
November 21													
Altitude	0.	1.	12.	21.	29.	34.	36.	34.	29.	21.	12.	1.	0.
Azimuth	*****	-65.	-56.	-46.	-33.	-17.	0.	17.	33.	46.	56.	65.	*****
December 21													
Altitude	0.	0.	9.	18.	26.	31.	33.	31.	26.	18.	9.	0.	0.
Azimuth	*****	*****	-54.	-43.	-31.	-16.	0.	16.	31.	43.	54.	*****	*****

Solar Angle Table at 36° N. Latitude

Solar Time	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	NOON	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM
January 21													
Altitude	0.	0.	10.	20.	27.	32.	34.	32.	27.	20.	10.	0.	0.
Azimuth	*****	*****	-56.	-45.	-32.	-17.	0.	17.	32.	45.	56.	*****	*****
February 21													
Altitude	0.	5.	17.	27.	35.	41.	43.	41.	35.	27.	17.	5.	0.
Azimuth	*****	-72.	-63.	-51.	-37.	-20.	0.	20.	37.	51.	63.	72.	*****
March 21													
Altitude	0.	12.	24.	35.	44.	51.	54.	51.	44.	35.	24.	12.	0.
Azimuth	-90.	-81.	-71.	-60.	-44.	-25.	0.	25.	44.	60.	71.	81.	90.
April 21													
Altitude	7.	19.	31.	43.	54.	62.	66.	62.	54.	43.	31.	19.	7.
Azimuth	-99.	-91.	-82.	-71.	-56.	-33.	0.	33.	56.	71.	82.	91.	99.
May 21													
Altitude	12.	23.	36.	48.	59.	69.	74.	69.	59.	48.	36.	23.	12.
Azimuth	-106.	-98.	-90.	-80.	-67.	-43.	0	43.	67.	80.	90.	98.	106.
June 21													
Altitude	14.	25.	37.	49.	61.	72.	77.	72.	61.	49.	37.	25.	14.
Azimuth	-109.	-102.	-94.	-85.	-72.	-50.	0.	50.	72.	85.	94.	102.	109.
July 21													
Altitude	12.	24.	36.	48.	60.	70.	75.	70.	60.	48.	36.	24.	12.
Azimuth	-107.	-99.	-91.	-81.	-68.	-44.	0.	44.	68.	81.	91.	99.	107.
August 21													
Altitude	7.	19.	31.	43.	54.	63.	66.	63.	54.	43.	31.	19.	7.
Azimuth	-100.	-91.	-82.	-71.	-56.	-33.	0.	33.	56.	71.	82.	91.	100.
September 21													
Altitude	0.	12.	24.	35.	44.	51.	54.	51.	44.	35.	24.	12.	0.
Azimuth	-90.	-81.	-71.	-60.	-44.	-25.	0.	25.	44.	60.	71.	81.	90.
October 21													
Altitude	0.	6.	17.	27.	36.	41.	44.	41.	36.	27.	17.	6.	0.
Azimuth	*****	-73.	-63.	-51.	-39.	-20.	0.	20.	37.	51.	63.	73.	*****
November 21													
Altitude	0.	0.	10.	20.	27.	32.	34.	32.	27.	20.	10.	0.	0.
Azimuth	*****	*****	-56.	-45.	-32.	-17.	0.	17.	32.	45.	56.	*****	*****
December 21													
Altitude	0.	0.	8.	17.	24.	29.	31.	29.	24.	17.	8.	0	0
Azimuth	*****	*****	-53.	-43.	-30.	-16.	0.	16.	30.	43.	53.	*****	*****

Solar Angle Table at 38° N. Latitude

Solar Time	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	NOON	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM
January 21													
Altitude	0.	0.	9.	18.	26.	30.	32.	30.	26.	18.	9.	0.	0.
Azimuth	*****	*****	-56.	-44.	-31.	-16.	0.	16.	31.	44.	56.	*****	*****
February 21													
Altitude	0.	5.	16.	26.	34.	39.	41.	39.	34.	26.	16.	5.	0.
Azimuth	*****	-72.	-62.	-50.	-36.	-19.	0.	19.	36.	50.	62.	72.	*****
March 21													
Altitude	0.	12.	23.	34.	43.	50.	52.	50.	43.	34.	23.	12.	0.
Azimuth	-90.	-81.	-70.	-58.	-43.	-24.	0.	24.	43.	58.	70.	81.	90.
April 21													
Altitude	7.	19.	31.	42.	52.	60.	64.	60.	52.	42.	31.	19.	7.
Azimuth	-99.	-90.	-80.	-69.	-53.	-31.	0.	31.	53.	69.	80.	90.	99.
May 21													
Altitude	12.	24.	36.	47.	58.	68.	72.	68.	58.	47.	36.	24.	12.
Azimuth	-106.	-98.	-89	-78.	-64.	-40.	0.	40.	64.	78.	89.	98.	106.
June 21													
Altitude	14.	26.	37.	49.	61.	71.	75.	71.	61.	49.	37.	26.	14.
Azimuth	-109.	-101.	-92.	-82.	-69.	-46.	0.	46.	69.	82.	92.	101.	109.
July 21													
Altitude	13.	24.	36.	48.	59.	68.	73.	68.	59.	48.	36.	24.	13
Azimuth	-106.	-98.	-89.	-79.	-65.	-41.	0.	41.	65.	79.	89.	98.	106.
August 21													
Altitude	8.	19.	31.	42.	53.	61.	64.	61.	53.	42.	31.	19.	8.
Azimuth	-100.	-91.	-81.	-70.	-54.	-31	0	31.	54.	70.	81.	91.	100
September 21													
Altitude	0.	12.	23.	34.	43.	50.	52.	50.	43.	34.	23.	12.	0
Azimuth	-90.	-81.	-70.	-58.	-43.	-24.	0.	24.	43.	58.	70.	81.	90.
October 21													
Altitude	0.	5.	16.	26.	34.	40.	42.	40.	34.	26.	16.	5.	0.
Azimuth	*****	-72.	-62.	-51.	-36.	-19.	0.	19.	36.	51.	62.	72.	*****
November 21													
Altitude	0.	0.	9.	18.	26.	31.	32.	31.	26.	18.	9.	0.	0.
Azimuth	*****	*****	-56.	-45.	-31.	-16.	0.	16.	31.	45.	56.	*****	*****
December 21													
Altitude	0.	0.	7.	15.	22.	27.	29.	27.	22.	15.	7.	0.	0.
Azimuth	*****	*****	-53.	-42.	-30.	-15.	0.	15.	30.	42.	53.	*****	*****

Solar Angle Table at 40° N. Latitude

Solar Time	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	NOON	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM
January 21													
Altitude	0.	0.	8.	17.	24.	28.	30.	28.	24.	17.	8.	0.	0.
Azimuth	*****	*****	-55.	-44.	-31.	-16.	0.	16.	31.	44.	55.	*****	*****
February 21													
Altitude	0.	4.	15.	24.	32.	37.	39.	37.	32.	24.	15.	4.	0.
Azimuth	*****	-72.	-62.	-50.	-35.	-19.	0.	19.	35.	50.	62.	72.	*****
March 21													
Altitude	0.	11.	23.	33.	42.	48.	50.	48.	42.	33.	23.	11.	0.
Azimuth	-90.	-80.	-70.	-57.	-42.	-23.	0.	23.	42.	57.	70.	80.	90.
April 21													
Altitude	7.	19.	30.	41.	51.	59.	62.	59.	51.	41.	30.	19.	7.
Azimuth	-99.	-89.	-79.	-67.	-51.	-29.	0.	29.	51.	67.	79.	89.	99.
May 21													
Altitude	13.	24.	35.	47.	57.	66.	70.	66.	57.	47.	35.	24.	13.
Azimuth	-106.	-97.	-87.	-76	-61	-37	0.	37.	61.	76.	87.	97.	106.
June 21													
Altitude	15.	26.	37.	49.	60.	69.	73.	69.	60.	49.	37.	26.	15.
Azimuth	-108.	-100.	-91.	-80.	-66.	-42.	0.	42.	66.	80.	91.	100.	108.
July 21													
Altitude	13.	24.	36.	47.	58.	67.	71.	67.	58.	47.	36.	24.	13.
Azimuth	-106.	-97.	-88.	-77.	-62.	-38.	0.	38.	62.	77.	88.	97.	106.
August 21													
Altitude	8.	19.	31.	42.	52.	59.	62.	59.	52.	42.	31.	19.	8.
Azimuth	-99.	-90.	-80.	-68.	-52.	-30	0.	30.	52.	68.	80.	90.	99.
September 21													
Altitude	0.	11.	23.	33.	42.	48.	50.	48.	42.	33.	23.	11.	0.
Azimuth	-90.	-80.	-70.	-57.	-42.	-23	0.	23.	42.	57.	70.	80.	90.
October 21													
Altitude	0.	4.	15.	25.	32.	38.	40.	38.	32.	25.	15.	4.	0.
Azimuth	*****	-72.	-62.	-50.	-36.	-19.	0	19.	36.	50.	62.	72.	*****
November 21													
Altitude	0.	0.	8.	17.	24.	29.	30.	29.	24.	17.	8.	0.	0.
Azimuth	*****	*****	-55.	-44.	-31.	-16.	0.	16.	31.	44.	55.	*****	*****
December 21													
Altitude	0.	0.	5.	14.	21.	25.	27.	25.	21.	14.	5.	0.	0.
Azimuth	*****	*****	-53.	-42.	-29.	-15.	0.	15.	29.	42.	53.	*****	*****

Solar Angle Table at 42° N. Latitude

Solar Time	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	NOON	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM
January 21													
Altitude	0.	0.	7.	15.	22.	26.	28.	26.	22.	15.	7.	0.	0.
Azimuth	*****	*****	-55.	-44.	-30.	-16.	0.	16.	30.	44.	55.	*****	*****
February 21													
Altitude	0.	4.	14.	23.	30.	35.	37.	35.	30.	23.	14.	4.	0.
Azimuth	*****	-72.	-61.	-49.	-35.	-18.	0.	18.	35.	49.	61.	72.	*****
March 21													
Altitude	0.	11.	22.	32.	40.	46.	48.	46.	40.	32.	22.	11.	0.
Azimuth	-90.	-80.	-69.	-56.	-41.	-22.	0.	22.	41.	56.	69.	80.	90.
April 21													
Altitude	8.	19.	30.	40.	50.	57.	60.	57.	50.	40.	30.	19.	8.
Azimuth	-99.	-89.	-78.	-66.	-50.	-28.	0.	28.	50.	66.	78.	89.	99.
May 21													
Altitude	13.	24.	35.	46.	56.	65.	68.	65.	56.	46.	35.	24.	13.
Azimuth	-105.	-96.	-86.	-74.	-58.	35.	0.	35.	58	74.	86.	96.	105
June 21													
Altitude	15.	26.	37.	48.	59.	68.	71.	68.	59.	48.	37.	26	15.
Azimuth	-108.	-99.	-89.	-78.	-63.	-39.	0	39.	63.	78.	89.	99.	108.
July 21													
Altitude	14.	25.	36.	47.	57.	65.	69.	65.	57.	47.	36.	25.	14.
Azimuth	-106.	-96	-86.	-75.	-59.	-35.	0	35.	59.	75.	86.	96.	106.
August 21													
Altitude	8.	19.	30.	41.	50.	58.	60.	58.	50.	41.	30.	19.	8.
Azimuth	-99	-89	-79.	-66	-50	-28	0.	28	50.	66.	79.	89.	99.
September 21													
Altitude	0.	11.	22.	32.	40.	46.	48.	46.	40.	32.	22.	11.	0.
Azimuth	-90.	-80.	-69.	-56.	41.	-22.	0.	22.	41.	56.	69.	80.	90.
October 21													
Altitude	0.	4.	14.	23.	31.	36.	38.	36.	31.	23.	14.	4.	0.
Azimuth	*****	-72.	-61.	-49.	-35.	-18.	0.	18.	35.	49.	61.	72.	*****
November 21													
Altitude	0.	0.	7.	16.	22.	27.	28.	27.	22.	16.	7.	0.	0.
Azimuth	*****	*****	-55.	-44.	-31.	-16.	0.	16.	31.	44.	55.	*****	*****
December 21													
Altitude	0.	0.	4.	12.	19.	23.	25.	23.	19.	12.	4.	0.	0.
Azimuth	*****	*****	-53.	-42.	-29.	-15.	0.	15.	29.	42.	53.	*****	*****

Appendix D:
Shadow Planning with Overlays

Shadow Planning with Overlays

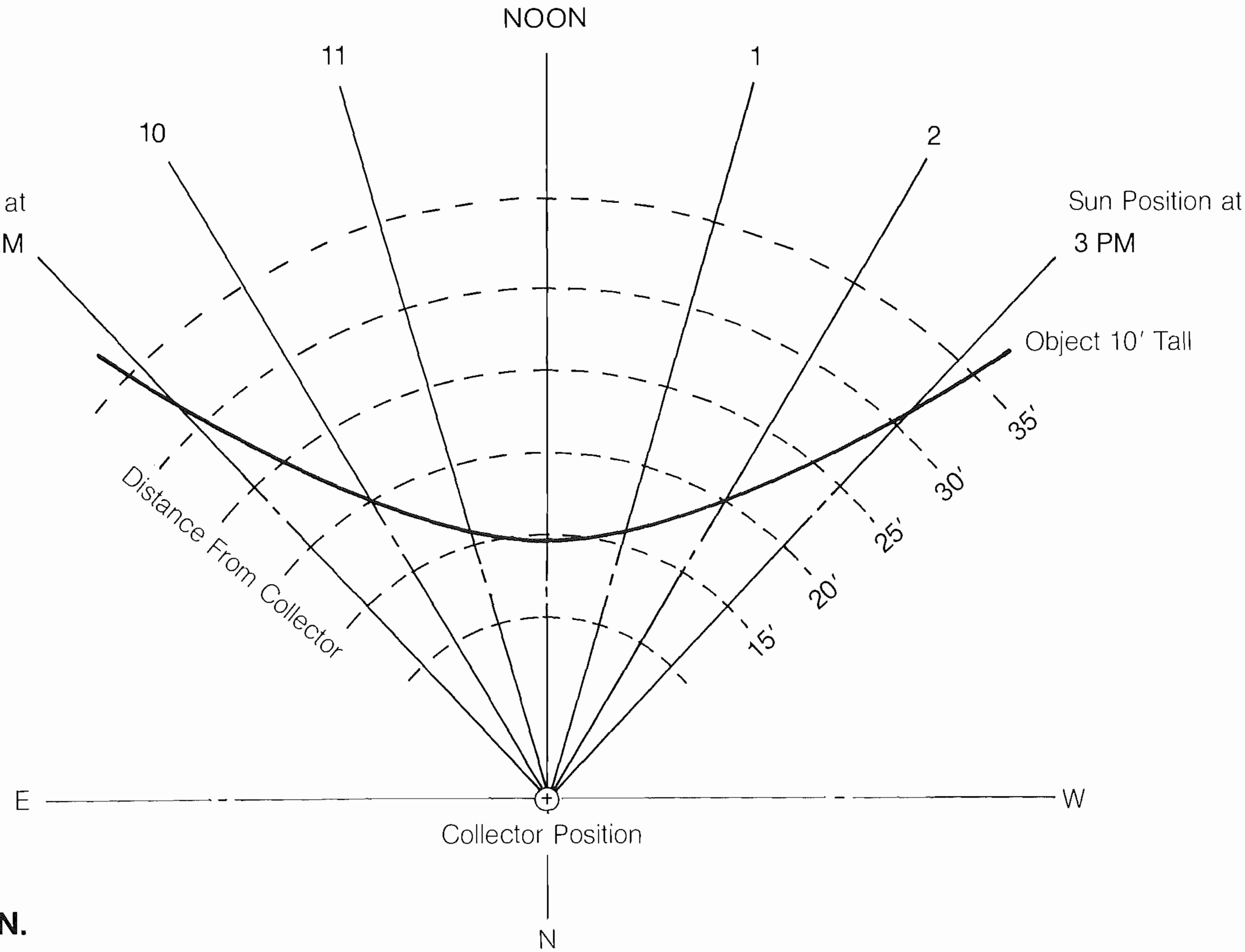
The shading effects of various objects can be evaluated with the following overlays provided for every 4° of California latitude. Align the overlay for your latitude on a site plan showing the collector and its potential obstructions. Orient the overlay relative to compass bearings. The arc shows how far back an object must be to avoid shading the collector. The overlays are drawn at a scale of one inch to ten feet (1″ = 10′) and the arc is for a 10 foot tall object.

For other scales of drawing, note the setback distance where the arc crosses a line between the potentially shading object and the collector; then rescale this distance on your site plan. If the object is between the collector and the scaled point, shading will occur.

For other object heights, simply multiply the setback distance by the factor $\left\{\frac{\text{actual object height}}{10}\right\}$.

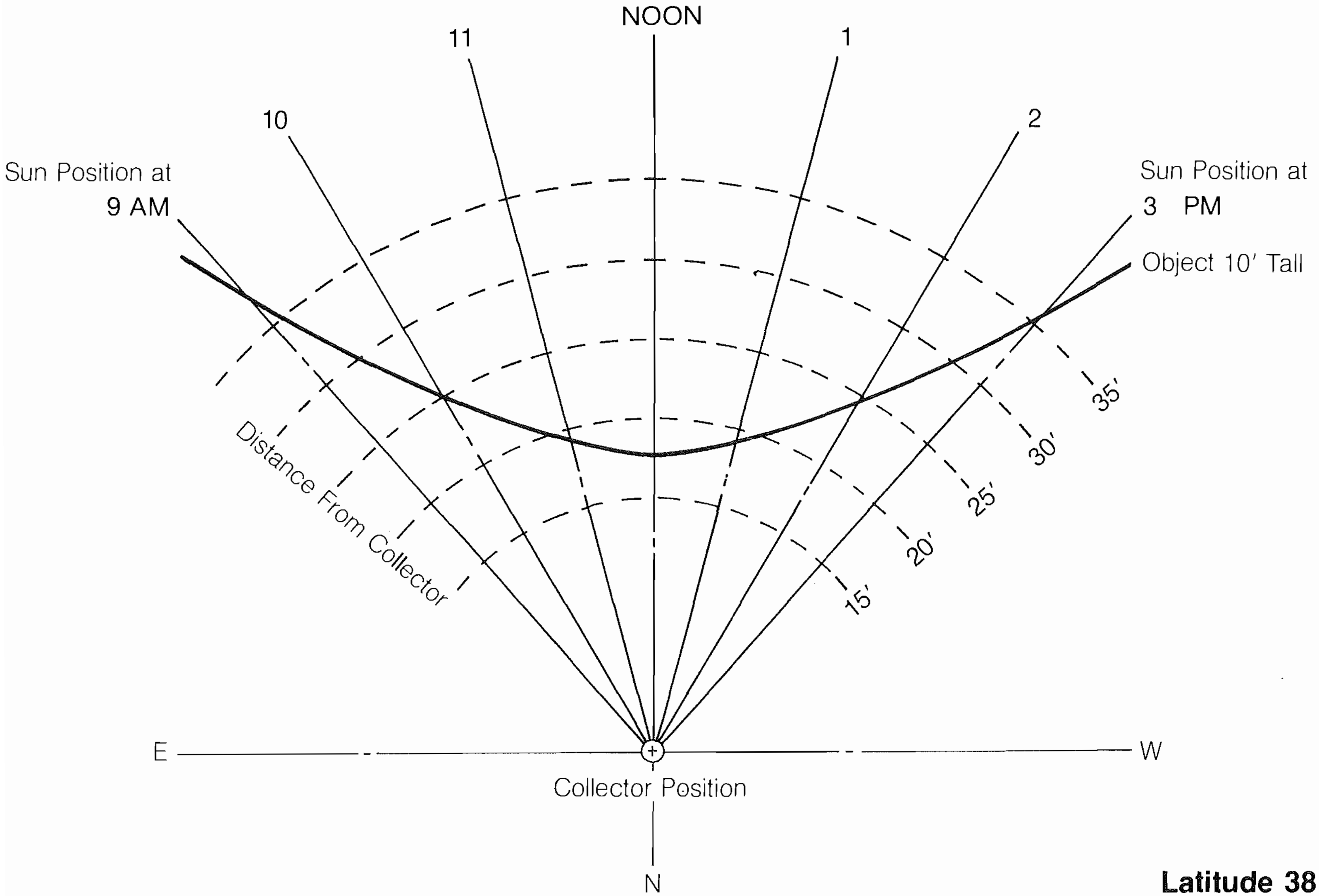
For example, a 25′ object would have to be 2.5 times as far from the collector as a 10′ high object $\left\{\frac{25}{10} = 2.5\right\}$.

To use the following overlay information, select the graph for the latitude closest to your site and trace or photocopy onto clear film to make an overlay.

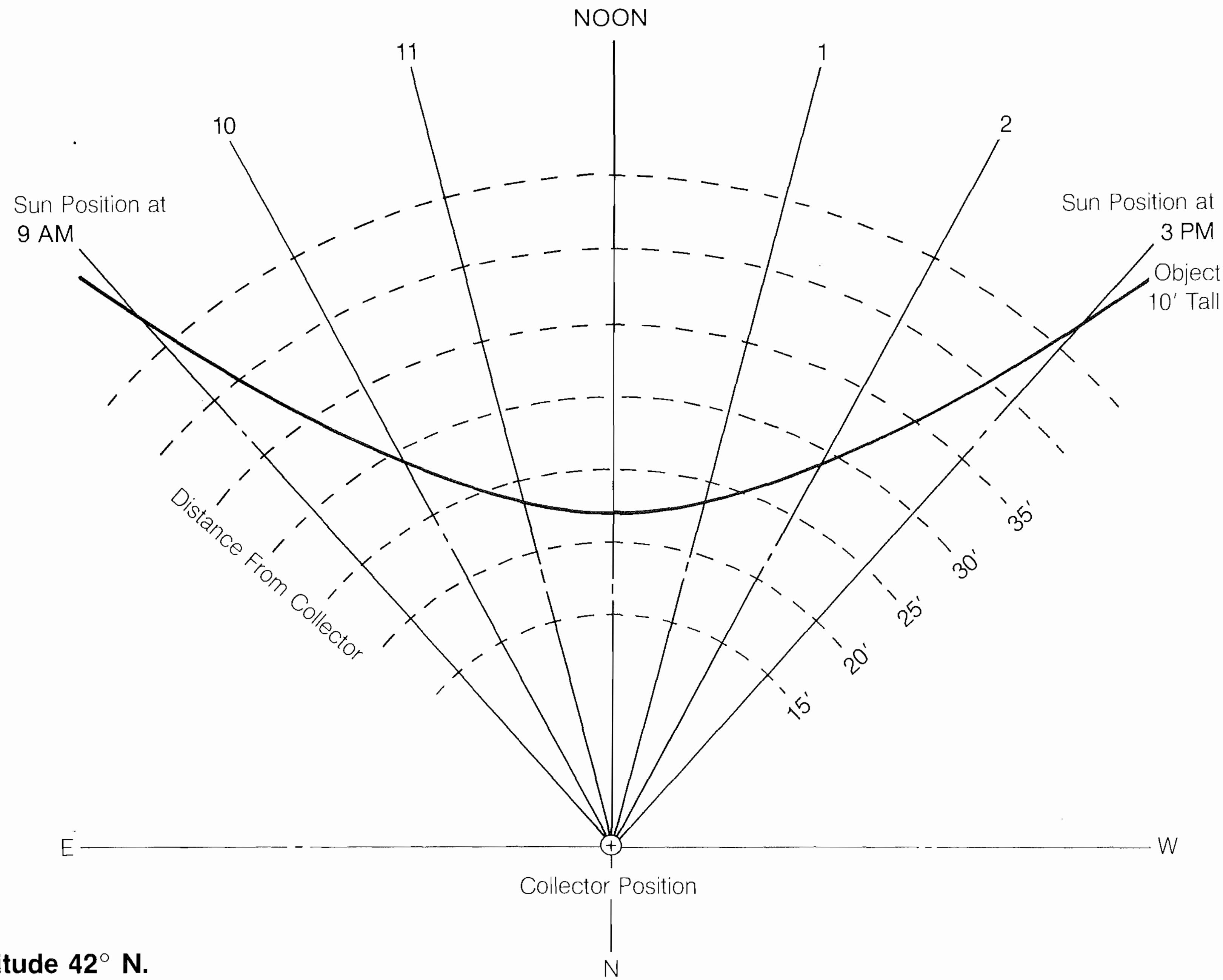


Latitude 34° N.

Scale: 1″ = 10′



Latitude 38° N.
Scale: 1″ = 10′



Latitude 42° N.
Scale: 1″ = 10′

Appendix E:
For Further Reading: An Annotated Bibliography

Planning solar neighborhoods is a relatively new field and there are very few books that cover it comprehensively. Information must be obtained from a variety of sources and gaps in the literature remain. The following books are recommended as sources on specific topics.

Reviews

Non-Technical Books: These books contain information that does not require the reader to have an extensive technical background.

Technical Books: These references require the reader to have some background in the material covered, though most of the information can also be understood by readers with no background who are willing to spend some time with the material.

Planning (Non-Technical)

A.I.A. Research Corporation. *Regional Guidelines for Energy-Conserving Homes,* 1978

A definition and analysis of thirteen climatic regions for the continental United States and Hawaii. The building guidelines range from conceptual considerations to choice of materials and details. Well illustrated.

Center for Landscape Architectural Education and Research. *Options for Passive Energy Conservation in Site Design,* available through National Technical Information Center, 1978.

A largely graphic, extensively researched presentation of principles and examples. It discusses the four classic climatic regions in the continental United States. Fun as well as informative. Good bibliography.

County Council of Sussex. *A Design Guide for Residential Areas.* Anchor Press, Ltd., London, 1973

An excellent British example of good neighborhood planning. Includes design standards for narrow streets, pedestrian walkways and a wide variety of key planning elements. Excellent illustrations.

Land Design/Research. *Cost Effective Site Planning: Single Family Development.* National Assoc. of Home Builders (NAHB), 1976.

A simple introduction to planning compact and energy efficient subdivisions. A good book for getting ideas about what's possible. The book discusses planning for energy conservation, but the examples used in later sections ignore good energy planning practices such as south orientation and climate considerations.

Living Systems, Jonathan Hammond, etal. *Davis Energy Conservation Report*, Winters, CA 95694, 1977.

This report describes the Davis Energy Conservation Project including the Energy Conservation Building code, planning for energy conservation, climate analysis, public education programs and solar homes. Although the analysis and program is specific to Davis, this report provides an excellent model for programs that can be done anywhere in the U.S.

Living Systems, Hammond, Hunt, Cramer & Nuebauer. *A Strategy for Energy Conservation*, Winters, CA 95694, 1974.

A basic text on energy conservation at the dwelling neighborhood and community levels. Gives a number of Davis studies on the performance of existing buildings as a function of their climate. Includes the Davis Energy Conservation Building Code.

National Association of Home Builders. *Land Development Manual,* 1974.

A valuable guide for the housing developer. Solar and energy-conserving topics are not emphasized but other basic planning considerations are well presented.

Ridgeway, James. *Energy Efficient Community Planning.* The JG Press, Inc., 1979.

An overview of the efforts of Seattle, WA; Davis, CA; Northglenn, CO; Hartford, Conn.; plus specific programs of other U.S. cities. Gives a good review of what is being done.

Planning (Technical)

California Energy Commission. *Protecting Solar Access: A Guidebook for California Communities,* 1980.

A basic text for planning officials. Beginning with a description of solar principles, it concentrates on how to implement them given California's existing legislation. Zoning, subdivision regulations and the environmental review process are covered in detail.

DeChira, J. and Koppelman, L. *Manual of Housing Planning and Design Criteria.* Engelwood Cliffs, NJ: Prentice Hall, 1975.

As indicated by the title, this book focuses on housing and subdivision planning and design criteria. This narrow focus makes this text useful for designers, planners, and developers. It provides some good examples of planned unit developments and attached houses. Some of the information clearly conflicts with the basic principles of solar design and energy efficient neighborhoods. Use it critically.

Lynch, Kevin. *Site Planning.* Cambridge, Mass.: MIT Press, 1971.

The classic text on site planning. While the book has only a small general section on microclimate and solar orientation, the standard parts of site planning such as roads and utilities are covered more thoroughly. Overall, the book treads the fine line between an engineering handbook and an architectural treatise on space, form and humane design.

Real Estate Research Corp. *The Costs of Sprawl,* U.S. Govt. Printing Office, Washington, D.C., 1977

A detailed economic analysis of environmental and social costs of urban sprawl. Presents a powerful case for mixed housing types and denser subdivisions. Slow reading but filled with useful charts and graphs.

Building (Non-Technical)

Adams, Anthony. *Your Energy Efficient Home.* Charlotte, VT: Garden Way Publishing, 1976.

A very basic, well illustrated introduction to site planning and building design for energy conservation. Contains little useful information on either direct (passive) or indirect (active) solar use or using other alternative energy sources.

AIA Research Corp. *Solar Dwelling Design Concepts.* U.S. Govt. Printing Office, Wash. D.C., 1977

Introduction to solar building design with an emphasis on active systems Many of the sample buildings discussed violate basic solar design principles such as unshaded east and west windows. Use critically.

Anderson, Bruce. *The Solar Home Book.* Harnisville, NH: Cheshire Books, 1976.

One of the best books on passive and solar home concepts and design in print. It also gives a good introduction to solar hot water systems. Well written with excellent illustrations. Much technical information is given for those interested.

Bainbridge, D.: Corbett, J. and Hofacre, J. *Village Homes Solar House Designs.* Emmaus, Pennsylvania: Rodale Press, 1979.

An excellent presentation of principles and numerous actual examples from America's favorite solar neighborhood.

Eccli, Eugene. *Low Cost Energy Efficient Shelter for the Owner and Builder.* Emmaus, PA: Rodale Press, 1976.

An excellent design manual on energy efficient houses for anyone considering designing and building a home. Includes many money-saving suggestions as well as excellent sections on windows, doors, vents and other key house components ignored in other books. Valuable for builders and architects too.

Leckie, Master, Whitehouse, and Young. *Other Homes and Garbage.* Sierra Club Books, San Francisco, 1975.

This book covers a wide variety of information on self-sufficient residential energy systems such as wind, water, methane as well as solar. The book includes a fairly good chapter on climatically adapted architecture and also provides a good introduction to active systems. The explanation of the ASHRAE methodology for calculating heat loss and heat gain of buildings is much clearer than the explanation in the original.

Mazria, Edward. *The Passive Solar Energy Book.* Emmaus, PA: Rodale Press, 1979.

Excellent. A well-organized and easy to comprehend collection of passive solar principles and applications. Its key asset is that it presents a series of rules of thumb for sizing the various elements. The illustrations are a delight.

Olgyay, V. and Olgyay, A. *Design with Climate.* Princeton, NJ: Princeton Univ. Press, 1963.

The classic book on climatically adapted building design and planning. This book is good for getting an understanding of principles of climatic elements and their interactions with building design, but it is not a design handbook for daily use.

Wade, A. and Ewenstein, N. *30 Energy Efficient Houses You Can Build.* Emmaus, PA: Rodale Press, 1977.

Beautiful photographs, drawings, house plans and narratives on solar and energy conserving homes. Lots of photos and information on building windows, skylights, and backup heaters. Excellent source of ideas for professional builders and owner builders.

Building (Technical)

ASHRAE. *Handbook of Fundamentals and Product Directory,* ASHRAE, New York, NY, 1972.

The standard reference for thermal analysis methodology and detailed information on thermal properties of materials. The handbook also contains excellent data on climatic design conditions, solar radiation, and window shading methods. Unfortunately, there are no sections specifically directed towards designing solar buildings. In addition, a large portion of the book consists of non-applicable information on refrigeration and industrial heating and cooling systems.

Egan, M. David. *Concepts of Thermal Comfort.* Englewood Cliffs, NJ: Prentice-Hall, Inc. 1975.

A well-illustrated basic text on the interaction between weather, construction materials, architectural mechanical systems and human comfort.

Geiger, R. *The Climate Near the Ground.* Cambridge, Mass.: Harvard Univ. Press, 1975.

A detailed scientific text which covers the principles of microclimatology, mainly in agricultural and forestry application. Much of the theory is applicable to building design and planning, but the format is difficult to use.

Givoni, B. *Man, Climate, and Architecture.* London: Elsevier Publishing Co., 1976.

A most comprehensive technical book on human comfort and the thermal performance of buildings. It contains excellent quantitative descriptions of the thermal performance of building materials and design features such as ventilation and window shading. This book is useful for those who want a detailed understanding about the interactions of people, buildings, and climate.

Knowles, R.L. *Energy and Form,* MIT Press, 1974.

Beginning with an excellent presentation on the ecological/energy networks of a series of primitive American cultures, Knowles projects the principles into a series of form generators, often highly theoretical.

Libbey-Owens-Ford. *Sun Angle Calculator.* Toledo, Ohio: Libby-Owens-Ford, 1975.

The easiest method around for calculating sun angles and profile angles for any orientation. The calculator covers the United States from 24°N Lat to 52°N Lat in 4° increments. Enhances the users' ability to visualize and generalize solar paths.

Olgyay, and Olgyay. *Solar Control and Shading Devices.* Princeton, NJ: Princeton University Press, 1957.

Duplicates some of the work in *Design With Climate,* but focuses on solar radiation as a key climatic influence. The abundant photographs provide an excellent catalogue of shading methods for buildings.

Strock, Clifford and Kozel, Richard. *Handbook of Air Conditioning, Heating and Ventilating.* New York, NY: Industrial Press, Inc., 1976.

An engineering manual similar to ASHRAE except it is much easier to read and use. The climatic data section is excellent and contains much information not contained in ASHRAE or other standard references. Strock also contains sections on thermal properties of materials and heat transfer equations. Overall, this is an excellent and very useful handbook.

Total Environmental Action. *Solar Energy Home Design in Four Climates.* 1975.

The book shows four solar homes that utilize both active and passive systems to provide heating, cooling and domestic hot water. The most interesting part of the book is the method of climate analysis, and fitting the building to the climate.

Vegetation and Landscape Planning References

American Society of Landscape Architects Foundation. *Landscape Planning for Energy Conservation.* Reston, VA: Environmental Design Press, 1977.

A comprehensive guide for planning with vegetation and landforms. Includes sections on site selection and analysis and site planning for solar architecture. A number of case studies are given for various climatic regions.

Beatty, Russell A. *Trees for Lafayette.* NCC/ASLA Publications Group, Oakland, 1975.

A delightful look at a California city and how to plan its trees. Full of climatically and horticulturally adapted tree lists for a number of situations. Fine illustrations.

Gault, S. Millar. *Color Dictionary of Shrubs.* New York, NY: Crown Publishers, Inc., 1976.

Description and colorplates of 506 cultivated shrubs. Excellent pictures.

Heritage Oaks Committee. *Native Oaks, Our Valley Heritage.* Sacramento County Office of Education, Sacramento, 1976.

A guide to the botany, planting and care of native oaks in the Sacramento Valley.

Hillier, Harold G. *Hillier's Manual of Trees and Shrubs.* New York, N.Y.: A.S. Bowes & Co., 1972.

A thorough guide to cultivated species and cultivars of woody plants for temperate climates.

Hoover, Robert and Betty. *Native Plants in Our Garden.* Published by the author, 1972.

A lively narrative about garden uses of many California native plants. Includes lists of climatic zones in which these plants most likely thrive, lists for different uses, and a list of sources.

Howard, Frances and Maino, Evelyn. *Ornamental Trees.* Berkeley; University of California Press, 1955.

Illustrated guide to 195 trees useful in California gardens. Information presented in factual, tabular form with silhouettes of tree form and foliage.

Kelly, Stan. *Eucalypts.* Sydney, Australia: Thomas Nelson, Ltd., 1969.

Brief descriptions of habitat and main characteristics with notes on cultivation of 250 species of Eucalyptus, all illustrated with watercolor plates.

Lanzara, Paola and Pizzetti, Mariella. *Guide to Trees.* New York, NY: Simon and Shuster, 1977.

Descriptions and excellent color pictures of 300 trees, many commonly cultivated.

Lenz, Lee. *Native Plants for California Gardens.* Rancho Santa Ana Botanical Garden, Claremont, California, 1956.

Best overall treatment of California natives for gardens.

Mathias, M.E. et. al. *Ornamentals for California's Middle Elevation Desert.* University of California Division of Agricultural Sciences Bull. 839. Berkeley, California, 1968.

A thorough study list of cultivated ornamental plants found in this region; includes climatic adaptation data.

Maino, Evelyn and McMinn, Howard J. *Manual of Pacific Coast Trees.* University of California Press, Berkeley, California, 1935.

Includes lists of trees for various uses in the Pacific coast states.

McMinn, Howard J. and von Rensselaer, Maunisell. *Ceoanothus.* Santa Barbara Botanic Garden, Santa Barbara, California, 1942.

Description of the genus and its use in gardens, parks, and roadside plantings.

Rehder, Alfred. *Manual of Cultivated Trees and Shrubs.* New York, NY: MacMillan Publishing Co., Inc., 1940.

A standard reference work on cultivated woody plants for temperate climates.

Robinette, Gary. *Plants, People, and Environmental Quality.* United States Department of Interior, Washington, D.C., 1972.

A general study of plants and their environmental functions with profuse illustrations.

Rowntree, Lester. *Flowering Shrubs of California.* Stanford, California: Stanford University Press, 1939.

Description and lists of native flowering shrubs for the landscape.

Sunset Books and Sunset Magazine. *New Western Garden Book.* Menlo Park, California: Lane Publishing Co., 1979.

The standard popular guide to gardening and cultivated plants for the western U.S. Particularly useful for climatic adaptation of various plants.

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16	Living Systems, Jonathan Hammond
18	Ted and Susan Van Syckel
28	Jim Morelan, AIA (Solar Gain, The California Energy Commission, 1979)
65	Living Systems, Jonathan Hammond and James Plumb
66	Village Homes, Michael Corbett
72	James Plumb
73	Living Systems, Jonathan Hammond and James Plumb
75	Living Systems, Jonathan Hammond and James Plumb
76	James Zanetto
83	Sun Trees; Tandem Properties and Trident Energy Systems
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91	Sun Trees; Tandem Properties and Trident Energy Systems
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141	Senda Nueva; Living Systems, Jonathan Hammond and James Zanetto
143	Ralph Knowles and Richard D. Berry; Student Designer– Paul Gutierrez (Solar Energy Concepts; sponsored by The Solar Energy Research Institute)
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