Chapter 9

# House Design Based on Climate

"Will passive solar heating and cooling work where I live?" Simply put, the answer is "Yes!" After all, the sun shines everywhere. However, the question is not "whether" it will work, but rather, "how." What is the best way for you to use the many applications we have described in this book? The most important factor influencing the answer to this question is climate.

## A Tradition of Regional Architecture

The amount of time the sun shines differs from one part of the country to another. Temperature variations are even greater. Wind conditions vary from calm to continuously windy. Some areas are arid, while others are humid.

It really wasn't so long ago that we used rather primitive methods of heating and cooling our homes: fireplaces in the winter and windows in the summer. We had limited access to materials to improve the thermal performance of our houses. We had to rely on local building materials such as logs, stone, adobe, or sod. Glass was scarce, window screen non-existent, and sawdust substituted for insulation.

Combined with the cultural diversity of the immigrating settlers, the forces of climate and limited building materials resulted in a rich variety of architecture from one region to another.

For example, the harsh winters and abundant forests of the North Country combined to give us the traditional saltbox. Its compact floor design is oriented to the south and is covered by a long north roof to shield it from the cold winter winds. In the Great Plains, sod substituted for wood, and subterranean shelters offered protection from harsh, winter westerlies. The oppressive humidity of the mid-Atlantic and Gulf states gave us narrow floor plans, floor-to-ceiling windows and doors, high ceilings, and broad overhangs for enhancing summer ventilation. In the Southwest, Spanish settlers used thick adobe walls and shaded courtyards with fountains to keep interiors cool during the summer and warm during the winter.

Simplified heating and cooling technology developed more quickly than improved materials and techniques for upgrading the thermal performance of houses, in part because of abundant and cheap energy. The result is that large central heating and cooling systems run by cheap energy compensate for climatically inappropriate house designs. For example, torrid summer solar gains through large west-facing windows in the arid Southwest have become as commonplace as horrendous heat loss through large north-facing single-layered windows in the brutally cold North. Building materials are easily transported from one part of the country to another at great energy expense. Petroleum based plastics imitate adobe in the north and window shutters in the south. Monotonous-looking subdivisions have become Anywhere, USA.

Now the era of unlimited cheap energy has passed. We again have the opportunity to design houses that work with the climate and not against it. To make best use of this opportunity, we must understand the wide variety of energy conservation and passive solar heating and cooling applications, so as to appropriately select a suitable combination for a particular climate. In doing so, we will obtain the highest possible comfort at the lowest possible expenditure for materials and energy.

## A Revival of Climate-Based Architecture

Climate, then, should have a major affect on your selection of energy conservation options and passive solar heating and cooling features, and, in turn, the architectural design of your house. The relationship between these factors and climate is discussed here to assist you with your choices. You will find that there are enough possibilities to offer the potential of near-zero heating and cooling' bills nearly everywhere in the country while still satisfying your other needs for a home.

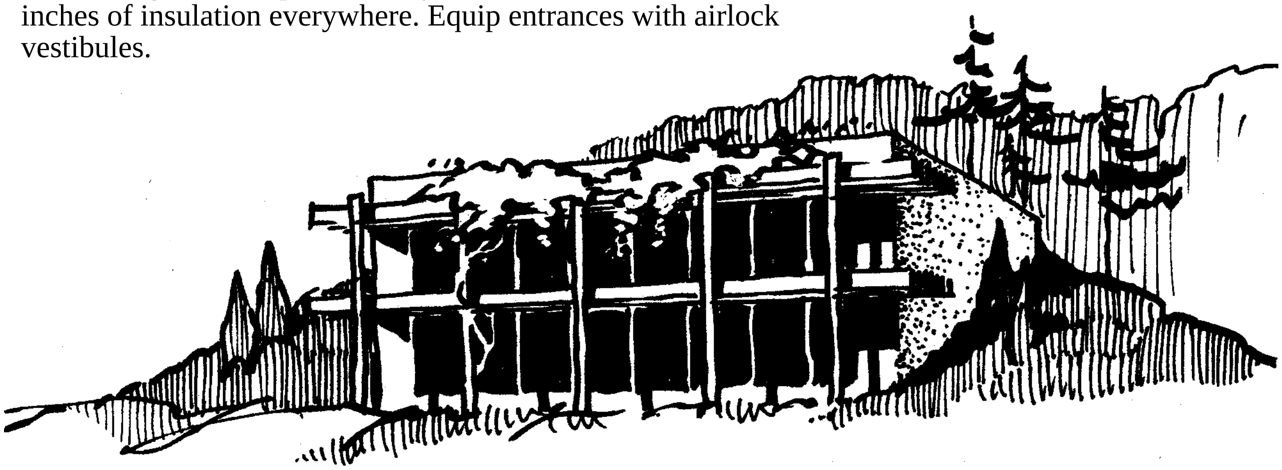
For simplicity, we can categorize climate into three types:

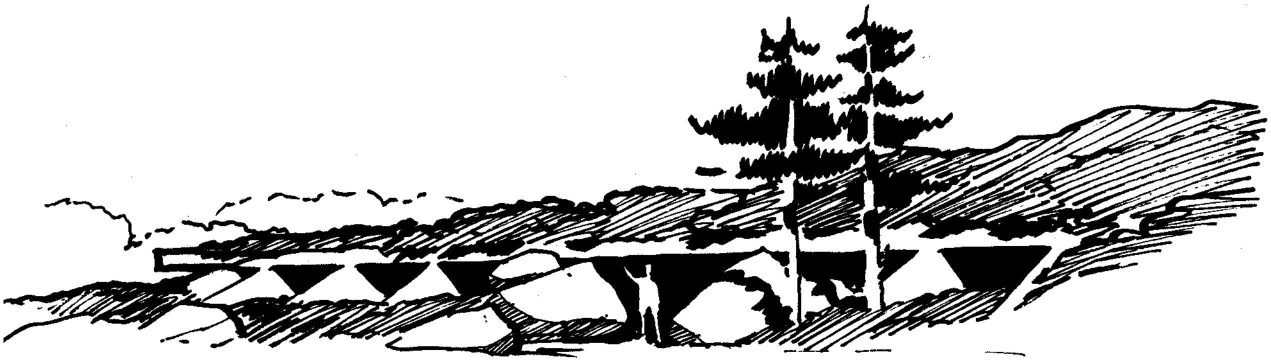
1. winter-dominated climates,
2. summer-dominated climates, and
3. climates that have a relatively balanced mix of winter and summer.

No doubt, you know which climate type you live in without having to look at a map of the country divided into the three zones. Besides, hills, valleys, lakes and rivers can cause your micro-climate to differ significantly from what a map would tell you.

## Winter-Dominated Climates

Northern New England, New York, the upper Midwest, and most of the Rocky Mountain highlands are typical of cold, winter-dominated climates. Make your house compact in shape and consider earth -sheltering if your soil and terrain is not too rough. Pay attention to construction details for minimizing air-leakage. Consider a heat reclaimer for introducing fresh air preheated by exhaust air. Use 10 to 15 inches of insulation everywhere. Equip entrances with airlock vestibules.

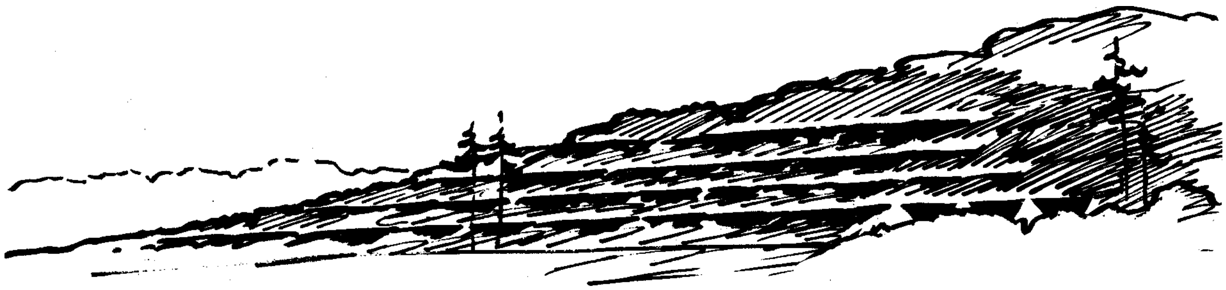




Locate most windows as close to due south as possible, but certainly away from cold winds, which usually prevail from north and west. If summers are mild, moderate-sized east- and west-facing windows will rarely create overheating problems. Avoid east- and west-facing glass where summers get hot. Alternatively, shade this glass well and, especially in humid climates such as New York, Pennsylvania and the upper Midwest, use them to admit cooling breezes. Roof overhangs can shade south glass and help trap gentle air currents for additional ventilation. Shade trees are particularly effective as "air conditioners" in winter-dominated climates that also have hot summers.

Many winter-dominated climates, such as much of the Rockies, experience mild summers, and cooling need not be a major consideration when designing a house to minimize winter fuel bills. Some parts of the Rockies, however, are hot during the day and cool at night. Therefore, thermal mass, important in this region in the winter for storing plentiful sunlight, can effectively store evening coolness to keep houses comfortable during the day. Supplementary evaporative cooling from pools, fountains, or "swamp" coolers may be needed in climates with hot, arid summers, such as the Great Plains and the plateaus of the Rockies.

In winter climates with abundant sunshine, such as Colorado and the Southwest, passive systems can be sized large enough to economically provide more than 75 percent of the heat. The greater the percentage of the heat



supplied by the sun, the more thermal mass is required for storing the excess heat for successive cloudy days. Thus, the most effective systems are solar windows in combination with concrete, stone, brick, or adobe construction and solar walls. The same mass keeps these houses cool in the summer.

In most of the rest of the country, the sun shines an average amount. Therefore, the choice of passive systems should be based on factors other than the availability of sun. For example, a greenhouse may be a good choice if additional moisture is desired in the house, but it may be a poor choice in a humid climate. On the other hand, a sun porch in a humid climate can be converted to a screened summer porch.

The thermal mass of large solar window systems and solar walls is not as appropriate in winter-dominated climates that are also mild. In the Pacific Northwest, for example, windows and solar rooms with wood-framed houses will suffice without thermal mass. The windows can be used for summer ventilation.

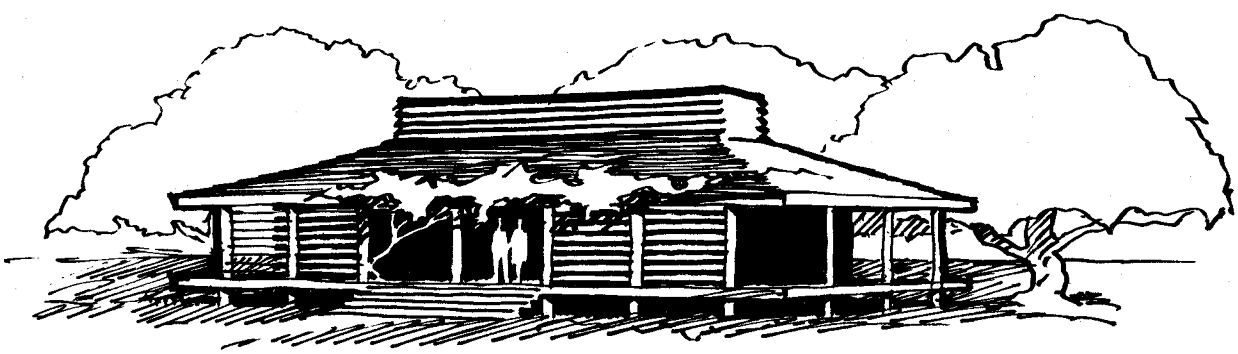
Because passive systems lose more heat in cold weather than in mild, windows and solar walls should have double glazing and movable insulation; triple glazing should be used in *really* cold climates, 9000 degree days or more. Solar chimneys should be double-glazed in really cold climates. They are relatively more cost-effective than other passive systems in colder climates. Solar rooms produce less heat and cost more in cold climates. There may be other reasons for building them, however.

The extra glazing increases the cost of a cold-climate passive system. And, since conservation saves more energy in cold climates than in mild ones, conservation can be carried "to extremes," and the passive system can be limited in size to 10 or 20 percent of the floor area. Active solar systems, too, can be considered seriously because long heating seasons increase their cost effectiveness. Solar water heating, of course, should be used regardless of climate. And be sure to slope your roof southward for future conversion to solar electric cells or to additional solar heating.

## Summer-Dominated Climates

At the opposite end of the thermal spectrum are climates dominated by summer. Some parts of the country, such as Hawaii, Southern California, and Florida, have no winter. Light, open construction permits houses to capture all available air movement. With proper shading, these houses should require no mechanical air conditioning other than occasional fans in humid climates and pools or fountains in arid ones.

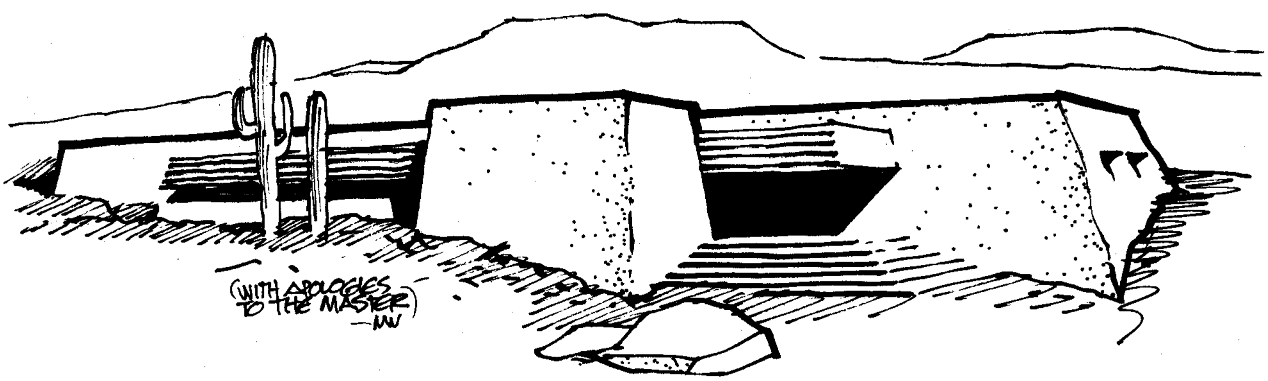
In summer-dominated climates, winters (if they exist at all) are usually quite mild. People tend to design houses that can be buttoned up easily when temperatures drop. A design dilemma then results, especially in humid climates such as the Gulf states. A house may be unable to be opened widely enough to permit sufficient cooling from ventilation. However, the same house may not be tight enough for efficient conventional heating and cooling.



A partial solution to this dilemma is a house that is both well insulated and well shaded. Windows should be double-glazed. For removing the winter chill, one third to one half of the total window area should face south. Properly designed houses will require little if any other heat in most winter climates of less than 3000 degree days per year.

The rest of the windows should be strategically placed to capture and enhance breezes. Locate large windows or vents as high as possible. Belvederes, turrets, gables, wind turbines and fans will add to the ventilating chimney effect. Place intake windows close to the floor and if possible, facing the winds. High ceilings help restrict warm air to levels above people's heads. Avoid shade trees in humid climates since they tend to stifle breezes, and their respiration adds moisture to air.

Make roofs light in color and vent all attic space well. Elevate houses slightly to assure good drainage and to minimize humidity. Carefully moisture-proof all floors and walls in direct contact with the ground but do not insulate unless cold, moist interior surfaces are considered undesirable. If you use earth pipes for cooling, make sure they are moisture-proof to avoid further humidification of incoming air by the ground. Since ground temperatures remain warm from the summer unless chilled by winter weather, this cooling method does not work in climates without winters. Even in climates with mild winters, the pipes must be buried more than six feet deep to obtain sufficiently cool temperatures.



In arid climates, earth contact can provide pleasant relief from hot weather and does not have associated moisture problems since humidity is often encouraged. Earth pipes can be perforated to increase humidification of the air by the ground.

Thermal mass is usually of little advantage in mild, humid climates. Solar windows and chimneys can accomplish most if not all of the heating. Solar chimneys can also be used to enhance summer ventilation. Solar walls are less applicable unless summer nights are mild, in which case the mass of the wall can help keep the house cool during the day. Solar rooms work best in humid climates if moisture respiration from plants is minimized. A good solar room in this climate is a sun porch which is easily converted to a screened porch during the summer.

In general, passive systems can be single-glazed. However, double glazing of windows can help eliminate the need for a heating system or, in less mild winters, reduce the size of the system to a single space heater.

The design strategy is somewhat different in arid, summer-dominated climates such as Southern California and the deserts of the Southwest. Conventional construction is of massive materials such as adobe. Tall, narrow east- and west-facing windows are recessed for easy shading. South walls of heavy materials need not be covered with glass or plastic in mild areas. They will provide adequate heat in the winter and can be shaded to reduce solar gains during the summer. East, west, and north walls can be insulated to reduce both winter heat loss and summer heat gain. The addition of a second layer of glazing to windows can eliminate fuel bills in many arid, summer-dominated climates. Extra south windows or a solar room may sometimes be needed to achieve this.

Cooling bills can also be eliminated by taking further steps. Pools, fountains, and other evaporative cooling techniques are ideal except where water is a scarce resource. Pool ponds and sprays work well, too. Sky radiational cooling is effective if night skies are clear, and solar roofs should be considered. Walls and roofs should be light in color to reflect summer heat.

## A Balance Between Winter and Summer

In many parts of the country, neither winter nor summer ' dominate. Year round mild weather prevails in, San Francisco and its environs, but in the Southern Midwest, both summer and winter are equally harsh. Southern New England is considered moderate.

First, the mild areas. These are the climates of greatest design freedom. Thick insulation, proper orientation, and a modest-sized passive system can all but eliminate heating bills. The solar roof house in Atascadero, California has proven that (see page 126).

Shading, thermal mass with night cooling, and ventilation can do most or all of the cooling. Sky radiational cooling using roof panels can also be used.

Moderate climates hold many of the same opportunities as mild climates; they offer numerous design choices. However, mistakes are not as forgiving so that more careful design is necessary. Elimination of backup heating and cooling is more difficult, but possible.

The best approach is to find local houses 50 to 100 years old that are comfortable both summer and winter. For your own design, retain their thermal properties and embellish them further with energy conservation and passive heating and cooling measures. Chances are, you will have a very successful, low-energy house.

Harsh climates may be either humid or arid. Review the earlier parts of this chapter, and combine heating and cooling measures that do not conflict with one another. Lots of insulation and multipaned windows, for example, rarely compete with other measures. It is the high fuel bills that are typical of these climates that offer both the substantial incentive and the substantial reward for using energy conservation and passive solar.