NATURAL COOLING: PRACTICAL USE OF CLIMATE RESOURCES

FOR SPACE CONDITIONING IN CALIFORNIA

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1. Introduction The primary focus of solar energy programs at both the State and Federal level has been on indirect (active) solar heating. Only recently has attention finally turned to direct thermal (passive) systems which offer the potential for both heating and cooling. Unfortunately, the emphasis has again been almost entirely on solar heating rather than on cooling. This paper offers an introduction to the methods and opportunities for natural cooling in California. Natural cooling will prove particularly important in California as an economical method of peak load reduction and therefore is an integral part of the Solar Office programs of the California State Energy Resources Conservation and Development Commission.

2. Natural Cooling Direct thermal and to a lesser extent indirect solar systems can be used for cooling if they are designed to utilize the local climate resource properly. Natural cooling has been utilized for centuries and has only recently been ignored, most obviously around 1950, as mechanical air conditioning and electricity became artificially cheap. Until then, the basic design features for natural cooling were incorporated in many, if not most buildings, in areas where cooling was required. Natural cooling has also been used for several thousand years to produce ice on warm nights in the Yahk Chal of Iran using radiant sky cooling.[1]

Natural cooling can use any or all of the four basic methods for cooling: solar control, convective cooling, evaporative cooling, and radiative cooling. Each of these will be described followed by a discussion of integrated design for natural cooling and a final section describing the potential for peak load reduction in California.

2.1 Solar Control The most cost effective method of natural cooling is solar control. It will always be the first step in reducing unwanted heat gain after the basic building shell is well insulated and weatherstripped. One of the most important factors for solar control is proper orientation with very few windows on the on the east and west, and most windows on the south. [2]

2.2 Convective Cooling After solar control has been incorporated in a building, further steps can be taken to increase natural cooling. One of the most economical and common methods of cooling will be convective cooling using low night or early morning air temperatures. Building design should incorporate full solar control and good ventilation to make use of convective cooling. The simplest solution is openable windows for through ventilation. In many areas thermal mass is needed to store enough nighttime "coolness" for a hot day.[2]

2.3 Evaporative Cooling If solar control and convective cooling cannot provide enough cooling then more powerful methods for natural cooling may also have to be incorporated in the building design. One of the simplest methods utilizes the evaporation of water.[3] The areas in California with the most severe cooling problems are ideally suited for evaporative cooling.

2.4 Radiative Cooling The final method of natural cooling is the use of radiant heat transfer for cooling. Radiation will flow from a hotter area to a cooler area and the night sky and north sky during the day are often quite cool. Systems can be designed to utilize night sky cooling or day north sky cooling from a surface shaded from the sun and facing to the north.[4,5,6] The Cool Pool concept developed by Living Systems looks very promising for low cost, highly effective cooling, Figure 1.[7]

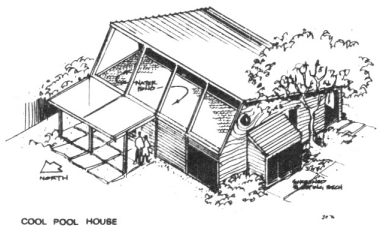

Figure 1 The Cool Pool

3. Integrated Design for Natural Cooling These four methods of natural cooling can provide full comfort throughout the summer in much of California. In most areas, the cost of natural cooling will be below the cost for mechanical systems particularly when the natural cooling system is an integral part of a direct thermal solar heating system. The following map illustrates the cooling methods appropriate for the different areas in California, Figure 2.

3rd Conf on the Use of Solar Energy for Cooling of Buildings, B. Clark ed.
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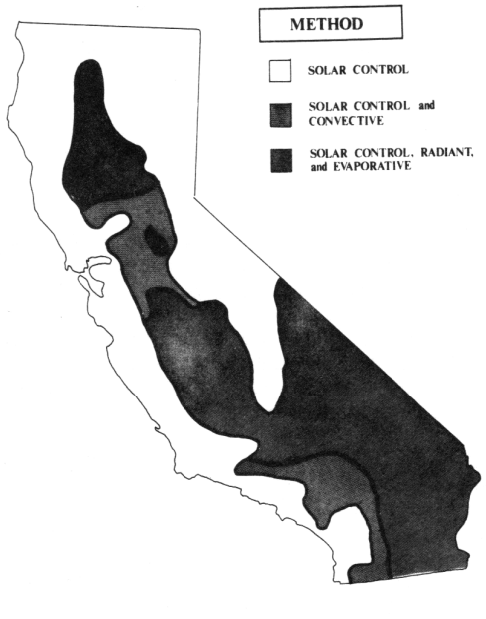

Figure 2 Natural Cooling in California

4. The Potential for Peak Load Reduction

Natural cooling can provide significant reductions in peak electrical demand at very low cost. This may perhaps be its most valuable function. This can be best illustrated with a house retrofit in the Central Valley. Every fifty square feet of west facing glass increases the heat load on a summer afternoon enough to require the addition of 1 ton of air conditioning. This in turn requires the addition of approximately two kw of capacity to system electrical generating capacity because it occurs at the summer peak. The approximate cost of the increased electrical generation capacity and air conditioner is around $2000. Alternatively, a bamboo shade on a permanent frame could be purchased and installed for about 50 dollars essentially eliminating the need for the addition cooling capacity.

The widespread application of natural cooling techniques to all new construction and through an aggressive retrofit education and incentives program to existing buildings could provide substantial energy savings in the Central Valley and in Southern California. A conservative estimate of potential savings is on the order of two billion dollars per year in California.

The Solar Office of the ERCDC is making an effort to bring this about through education, incentives, and regulations. The Solar Tax credit provisions favor those systems which provide both heating and cooling.[8] The mass marketing incentive program now being developed will also emphasize passive space conditioning, including cooling.[9]

References

1. Hay, H. (1976) "Atascadero Residence" Passive Solar Heating and Cooling Conference: Albuquerque, LA 6637-C NTIS.
2. Hammond, J., Hunt, M., Neubauer, L.W., and R. Cramer. (1974) A Strategy for Energy Conservation, Living Systems, Winters.
3. Bainbridge, D., and M. Hunt. (1976) "The Indio Cool Pool Experiment," Indio Energy Conservation Project, City of Indio, Indio, CA.
4. Goss, J.R. (1956) "Cooling of Water by Nocturnal Radiation and Evaporation," M.S. Thesis, Agricultural Engineering, U.C. Davis.
5. Neubauer, L. and Cramer, R. (1965) "Diurnal Radiant Exchange with the Sky Dome," Solar Energy, v. IX, n. 2.
6. Kelly, C.F., Bond, T.E., and N.R. Ittner. (1975) "Cold Spots in the Sky May Help Cool Livestock," Agricultural Engineering, October.
7. Bainbridge, D., Hammond, J., and B. Kopper (1976) "Cool Pool System," Davis Energy Conservation Report, Living Systems, Winters.
8. DeAngelis, M., Bainbridge, D. et al (1978) Staff Report: In Support of Guidelines and Criteria for the Solar Tax Credit, ERCDC
9. Fazio, V. (1977) California Assembly Bill 1512. signed into law 9/27/77.