Adobe as a Socially Appropriate Technology for the Southwest: Solar-Adobe Sundwellings

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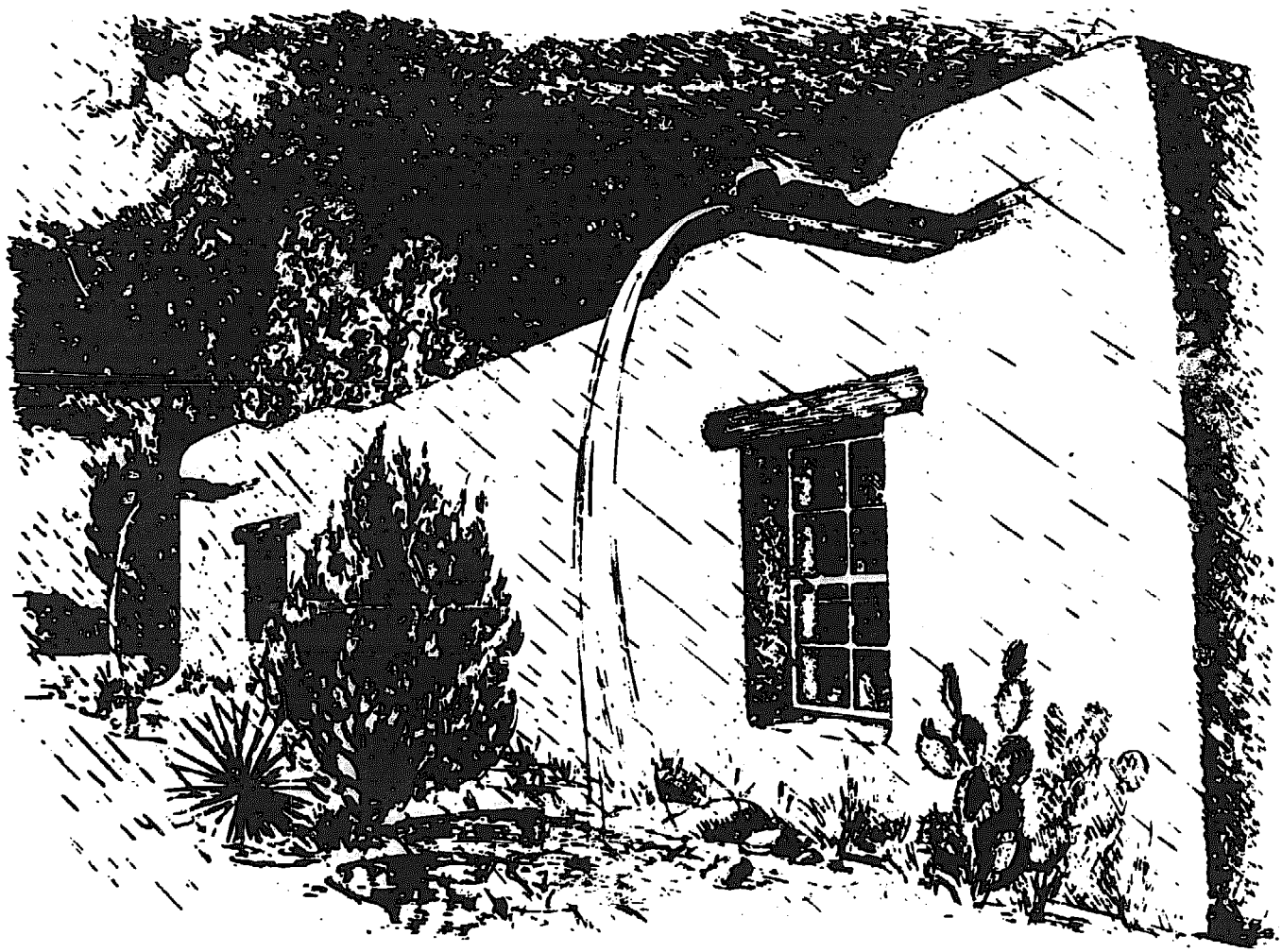
Adobe As A Socially Appropriate Technology For The Southwest or, The Solar-Adobe Sundwelling

ADOBE AS A SOCIALLY APPROPRIATE TECHNOLOGY FOR THE SOUTHWEST

John Timothy Mackey



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SOLAR-ADOBE HOUSING FOR THE SOUTHWEST IN THE '80s

Solar-adobes may become a regional model for affordable and energy-saving housing in the next decade. The successful completion of the Homegrown Sundwellings Project in northern New Mexico, and other research on adobe, has aroused national interest in the potential applications of this traditional builing material of the Southwest.

The rising cost of housing and the energy crisis of the Seventies has considerably transformed our attitudes toward indigenous building materials and "appropriate technologies" like adobe. Solar heating and cooling, known to us in principle for years, were initially greeted with skepticism. Adobe housing has also encountered opposition--from local officials and building codes, to various Federal regulations for standardizing building designs and construction. Indeed, a process so simple as adobe home building seems to have confounded many of our modern society's "experts."

Adobe--natural soil or the bricks which are made from it--has been used to build shelter in almost all countries and civiliations of the world. The

first use of adobe bricks in the Southwest was by the American Indians of the region. The practice was adopted by the Spanish and European settlers upon their arrival. With the advent of mass-produced stucco housing in the 1940s and 1950s, however, adobe began to rapidly decline in use. The loss of the art of adobe construction signaled the death of a unique southwestern culture and way of life.

However, adobe has been shown to be a low-cost, easy to use, energy-conserving building material. And, ironically, this has been known to the native inhabitants of the Southwest for centuries. Here is what recent research indicates:

- Under the conditions of resource scarcity, adobe could be the building material of the future: its's economical; soil may be secured at little or no cost. It uses the materials at hand so energy costs for transportation are minimal. Scarce and expensive timber resources can be saved for more appropriate uses. Also, with the addition of stabilizers, the bricks can be made in any climate.

- Adobe, when compared with most other building materials, is cooler in the summer and warmer in the winter, due to a natural process that is only beginning to be fully understood. Because of this, heating and cooling costs are substantially reduced.

- Adobe construction is labor-intensive and requires no special skills for the most part. Human effort is partially substituted for capital, and machines with the fuel needed to run them are not a part of the construction process. Because of this, more employment opportunities can be created. The work is especially well-adapted for self-help or cooperative building efforts.

- Barring serious earthquake or sloppy maintenance, a well-made adobe structure will last for generations. It's fireproof, and decay and termite-proof.

In many parts of the Southwest, prospective home-builders are taking a fresh look at other benefits also. The average resident of the region is attracted by the charm of adobe homes with their graceful architecture, earth colors, and soft lines. Many speak of the beauty and tranquility old adobe emanated, and some long for a return to the entirely adobe environment.

What has begun to again interest the government in adobe, is the incredible energy savings that may be realized in adobe homes. The adobe seems to have a peculiar tendency to "store" heat within it's walls during the daytime, then releasing this heat to warm the inside of an adobe home during the night. Because this process is a cyclical one that is

repeated each day and night, it is probably the most interesting example of a wholly natural heating and cooling system, an interaction between the sun and earth to provide comfortable indoor habitation at little or no cost. The U.S. Department of Housing and Urban Development and the U.S. Department of Energy, along with the State of New Mexico, are now spending about a half million dollars to study how this process actually works.

The most significant demonstration of adobe's potential is the Homegrown Sundwellings project, a "solar-adobe" housing research and demonstration effort recently completed in northern New Mexico. Begun in mid-1974 by a consortium of four southwestern states called the Four Corners Regional Commission, the program was conceived as a means of strengthening the traditional skills of the citizenry in the use of universally available natural resources (mainly sun, earth, and timber). Over a short period, a small team of leading architects, scientists, and solar researchers--among them, the nationally recognized architects David Wright and Peter Van Dresser--directed the construction of four solar-adobe dwellings identical in size and building materials. Three of the adobe buildings were equipped with different types of passive solar energy systems, such as a trombe wall and solar greenhouse. The fourth building uses only the adobe wall for passive solar

gain. The total construction cost for all four buildings was only $25,000 each. They are currently being used as a demonstration site and to house guests of the Ghost Ranch Conference Center in northern New Mexico, where they were built. At the same time, the Los Alamos Scientific Laboratory is monitoring the indoor temperatures of the buildings and is reporting success with all four units, even in times of extreme temperature fluctuations.

The Sundwellings concept goes beyond only economic concerns to the practical statement of a new ethic and community lifestyle. The interaction of human resources with the immediate materials of the land suggests solutions for our national energy crisis and economic problems, while protecting land, air, and water from the misapplication of modern technologies. Solar-adobe habitats point the way to a simpler, and yet more enriching lifestyle for those who choose to live in harmony with our natural environment.

* * *

I. INTRODUCTION

This paper is an attempt to assess the use of adobe as a modern building technology from the appropriate technology perspective. Therefore, it brings together discussion of the defining characteristics of appropriate technologies, social impact assessment of technology, and examines the use of adobe in light of the nation's energy/resource crisis and the increasing cost of housing.

The next section of this paper will define the unique characteristics of appropriate technology and the reasons for assessing the social impacts of technology. Adobe is introduced as an example of an appropriate technology and as a case study of technology assessment. The section concludes with a brief summary of adobe's value as a socially appropriate building technology for the southwest.

The history and culture of adobe is examined in the third section. Particular attention is given to the social and aesthetic implications the use of adobe had for the Spanish southwest and the primary role of women laborers in the traditional adobe construction process.

Section four of the paper takes a look at the present day potential for adobe in the economic development of poor rural areas in the Southwest. It is noted that adobe can benefit the local economy of rural communities in the Southwest and increase self-reliance. The potential for cooperative endeavors in adobe manufacturing is also described.

Section five examines more technical issues in the area of energy and resource conservation. The resource-conserving nature of the adobe construction process is explained and the thermal performance of adobe is examined in some detail. Adobe is shown to have been, for hundreds of years, a natural energy-conserver for the native populations, but with great potential for similar applications today.

Finally, recent developments and practical applications of adobe are noted, without an attempt to be comprehensive. Instead, the Homegrown Sundwellings Project -- a "solar-adobe" housing development -- is presented as a national model for low-cost, energy and resource conserving, self-help housing production.

II. SOCIALLY APPROPRIATE TECHNOLOGY

"Every people that has produced architecture has evoked its own favorite forms, as peculiar to that people as its language, its dress, or its folklore. Until the collapse of cultural frontiers in the last century, there were all over the world distinctive local shapes and details in architecture, and the buildings of any locality were the beautiful children of a happy marriage between the imagination of the people and the demands of their countryside."

- Hasan Fathy
Architecture for the Poor

In his book, Small is Beautiful,[1] E. F. Shumaker coined the term "intermediate technology" to describe "a technology of production by the masses, making use of the best of modern knowledge and experience, conducive to decentralization, compatible with the laws of ecology, gentle in its use of scare resources, and designed to serve the human person instead of making him the servant of machines . . . One can call it self-help technology or democratic or people's technology -- a technology to which everyone can gain admittance and which is not reserved to those already rich and powerful."

According to Ken Darrow in Appropriate Technology Sourcebook,[2] this "technology is especially

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[1]E. F. Shumaker, Small is Beautiful: Economics As If People Mattered (Harper and Row: 1972).

[2]Ken Darrow, Appropriate Technology Sourcebook.

attractive because it seems to solve a number of problems at once. Because it involves self-reliance and local production to meet local needs, on a national level, this approach can remove from the list of obstacles to (economic) development many of the inequities of a . . . system that is dominated by expensive technology and economic power."

There are a number of definite characteristics associated with any appropriate technology, although the term is not easily boxed into a fixed definition. One of the essential characteristics of appropriate technology is that it is low in capital costs and labor-intensive, creating and employing local skills and labor. It is this aspect of appropriate technology which makes it so well suited to the needs of underdeveloped areas, both in the United States and abroad, although its logic contradicts those who regard economic development as a capital-intensive process. But no one can safely promote technologies that demand high capital costs and contribute to economic development patterns which result in a need for <u>less</u> physical labor when the current need in underdeveloped areas is exactly the reverse.

A second characteristic of appropriate technology is that it uses local materials and utilizes locally available energy sources wherever possible. The day of the large-scale unit

appears to be coming to an end because of energy transport costs. We have developed hugh technologies on the basis of cheap transport. Such a system is possible only because of large-scale production with energy and transport costs that are minimal. We developed centralized points for the manufacture of needed products on the assumption that the cost of transporting these products to the areas where they were needed would be minimal. With the high energy costs for the transportation of materials, our alternative can be a return to decentralized points of production and the use of materials that are locally available and which utilize local sources of energy. Local communities can begin to increase tneir self-reliance until they will become self-sufficient to a large degree in providing for their basic needs. This makes possible greater individual and local community control over these important areas of community livelihood.

A third characteristic of appropriate technology, closely related to the preceding characteristics, is that it is understandable to the people who are using it, and can be produced, controlled and maintained by local communities without over-reliance upon highly-skilled technicians or professionals. The importance of the role of professionals and technicians has often been over-emphasized to the point where communities have felt they could not do without them in achieving their developmental goals. However, in many cases professionals merely work to counteract

problems created by technology or its incorrect application. This phenomenon is increasing in modern societies. An example is the field of medicine, where we know that prevention of harmful habits and environments will eliminate most major diseases. Instead, we choose to "invent" a highly-skilled professional class that merely attempts, through highly capital-intensive and expensive methods, to "patch up" outbreaks of disease without solving the root causes of disease through its prevention in the first place. The professionals have become colonials in the sense that they have taken possession of their knowledge of technology and established themselves in powerful positions over important aspects of life. The use of appropriate technologies lessens reliance upon professionals and specialists, making these skills more available to all persons while attempting to reduce the costs of development.

Social Impacts of Technology

While quite a bit of attention has been directed to the technical aspects and economic implications of technology for communities both here in the United States and abroad, the attention paid to the social impacts of the introduction and use of various technologies has been limited. Part of the reason for this has been that the social impacts of a technology have been very hard to quantify, especially in terms of the technology's effect upon culture and social patterns. The social and environmental costs of technology are

rarely examined along with the economic costs or benefits of such technology, even though it has become obvious that these types of costs are vitally important in the long-term, not only because they affect the economic livelihood of a community, but because they impact the health and safety of the community and the capacity of the natural environment to support the community's future existence. We now realize that a technically and economically sound technology may be socially and environmentally unsound. We also realize that a technology which is socially and environmentally inadequate also stands a good chance of being economically unsound in the long run.

Unfortunately, the attempt at a comprehensive understanding of the social and environmental impacts of various technologies has been limited because of the complexity of analyzing all of the constituent elements in the introduction or use of a technology. We can try to extend our analysis of the economic costs and benefits of a technology to follow the movement of capital goods, personnel, materials, energy, and information. But such an analysis, particularly when it reaches the level of the impact on the individual person's health or the social and cultural well-being of a community, is difficult. And this is only part of the problem. The attempt at quantification of social, environmental, and long-term economic costs or impacts also assumes that we can only look upon questions such as these and answer

them within the limited conceptual framework of linear-analytical modes of processing numerical information. This limits our perspective. Frequently this method results in what E. F. Schumaker called "optimizing the arrangement of deck-chairs on the Titanic."

Technology Assessment: Adobe

The assessment of building technologies or materials in the past exclusively considered the immediate economic cost in making judgments concerning their application. In doing so, these decisions were again limited in their perspective and our environmental crisis can be seen as one reflection of this mentality. The purpose of this report is to examine one building technology, adobe, from a comprehensive perspective that includes within its framework for analysis social and environmental considerations, in addition to economic costs and technical merits, to show that adobe is a socially appropriate technology for the Southwest. In assessing the traditional building technology of adobe, we will evaluate adobe relative to other building technologies and materials by using the following criteria:

- which type of building material lasts longer;
- which type of building material conserves energy and natural resources more efficiently;

- which type of construction creates more jobs and requires less technical skill and capital investment;

- which type of building material is locally available and better suited to the southwest bio-region where construction occurs;

- which type of building material and eventual home is better adapted aesthetically to the local environment and the local cultural values of the community.

These important factors in the design and construction of housing in the Southwest, particularly on Indian reservations, have long-term consequences for our success in providing housing. A factor such as whether or not one type of building material is aesthetically better adapted tc the local cultural values of the community where it will be used for habitation also has a "cost" component in the long-term. For example, Indian reservations around the United States are replete with examples of run-down, poorly maintained, modern wood frame constructed homes. These buildings last only a few years because they are not adapted to their environment and their Indian inhabitants refuse to maintain them. In the long run, examples such as these cost the government much more to provide decent habitation than traditionally designed homes which are adapted

from years of experience to the local environment and culture, and which utilize indigenous building materials and methods.

Adobe is one such indigenous building material which has been used traditionally by all inhabitants of the Southwest at one time or another, and is currently used by a majority of the world's population in similar climatic areas. The use of adobe in the Southwest has long-term social and environment benefits, in addition to technical and economic benefits. These include the following:

- Under the conditions of resource scarcity, adobe could well be the building material of the future -- it's economical; soil may secured soil at little or no cost. It uses the materials at hand, so energy costs for transportation are minimal. Earth construction saves increasingly scarce and expensive timber products for more appropriate uses. With the addition of concrete or asphalt stabilizers, the bricks can be made in almost any climate.

- Adobe, when compared with certain other types of construction, is cooler in the summer and warmer in the winter, the result of an interaction of insulation and mass that is only beginning to be understood. Because of this, heating and cooling costs are substantially reduced and energy is conserved.

- Barring serious earthquakes and sloppy maintenance, a well-made adobe structure will last for generations. It's fireproof, and decay and termite-proof.

- Adobe construction is labor-intensive and requires no special skills for the most part. Human effort is in some measure substituted for capital, and energy-muscle power is used instead of machines and the fuel necessary to operate them. Because of this, adobe construction creates more employment opportunities for those without special skills or training. It is also particularly well-adapted for self-help and cooperative building construction.

- The Chinese even claim that adobes, taken out of the walls of a well-used house and pulverized, make good fertilizer.

Ironically, we will also show in this paper that the use of adobe as an appropriate technology has been an important part of the traditional wisdom of the native inhabitants of the Southwest for hundreds of years; who, without the complex and expensive technical, social, and economic analyses apparently necessary nowadays, knew all of the multiple benefits to be derived by a local economy and community from the use of this fascinating indigenous building material -- the earth.

III. ADOBE: HISTORY AND CULTURE

> "The old among us can still remember an entirely adobe environment, whole towns of nothing but graceful adobe structures, earth colors, and soft lines . . . But I would still feel alittle melodramatic, trying to convince you that it was fantastically, unbelievably wonderfully beautiful! It actually made you feel better just to look at! It was harmonious, serene and restful . . . The beauty and that peculiar tranquility old adobe emanated was not only a quality of the medium itself, but also of the style, the refined-by-centuries way of doing things in a certain way."
>
> - Anita Rodrequez, "Adobe Traditions in Northern New Mexico"

Natural earth, or adobe,[3] has been used as a building material in almost all countries and by almost all civilizations around the world. Although its use has been more widespread in the tropical climates of the Middle East, North and East Africa (especially along the Nile), Central and South America, adobe has also been used as an indigenous building material in Spain, Northern America, and even in Wales. Most of the great

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[3]The word "adobe" used so commonly in the Southwest originated in Spanish and Moroccan roots, which meant "to mix" or 'puddle," and later came to be applied to both a sun-dried brick or to a structure built of that material. The term is used here as a generic term, including all techniques or methods of incorporating natural earth (soil) into the walls of buildings or homes. The terms "adobe construction" and "rammed earth construction" are also used interchangeably in this paper to refer to the building of structures with the adobe brick or a variety of natural soil.

architecture of the Middle East, such as beautiful mosques of Iran and Afghanistan, was built with adobe or fired earth. These buildings are still standing, decorated inside and out with multi-colored glazed tiles set in geometric designs. The adobe structure with the thatched or domed roof is one of the most common sights in many parts of the world.[4]

It has been estimated that half of the world's population now lives in houses built with adobe or variations of natural earth. Since World War II, many housing programs in the underdeveloped nations have relied heavily on adobe or rammed earth construction because the material is readily available, skills for making and laying the brick are widespread and easily learned, required capital investment is low, insulation is adequate, and, if labor costs are low, total construction cost is relatively cheap.[5]

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[4]The dome has been shown to be natural and efficient passive cooling system for hot climates, known to the inhabitants of Middle Eastern nations for thousands of years. See Mehdi N. Bahadori's article on "Passive Cooling Systems in Iranian Architecture," in the February 1979 issue of Scientific American.

[5]Four Corners Regional Commission, A Study of the Feasibility of Mechanized Adobe Production (Center for Environmental Research and Development, University of New Mexico: 1970-1972)

In the Americas, earth construction dates back to antiquity.[6] There are elaborate structures of earth found in Chan-Chan, Peru and at Casa Grande, Arizona. The former is thought by some archaeologists to be of an age comparable to that of the biblical civilization excavated in Mesopotamia, and the Casa Grande was so old as to be an object of veneration to the natives when the first Spanish explorers entered the region in the seventeenth century. What is said to be the first building erected by the Spanish immigrants in what is now the United States is the Palace of the Governors, built in Santa Fe, Mexico, in 1609 of sun-dried, adobe brick.[7] Anita Rodrequez, in an article on adobe traditions in the area of Northern New Mexico, describes the interchange of cultures when the Spanish first entered the area, and the division of labor which developed from the ancient Indian ways of using adobe in construction thusly:

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[6]Long, J. D. and Nuebaur, L. W., Adobe Construction, College of Agriculture - California Agricultural Experiment Station, University of California, Berkeley (November 1946, Revised), Bulletin #472. Much of the history on past and present use of adobe is derived from this publication.

[7]Originally used as a seat of the territorial government, it is still standing today and in use as a state museum.

> The native architecture of Northern New Mexico is unquestionably the oldest in the United States. It is a tradition deeply rooted in our Indian past and one already established before the introduction of European influences. The Rio Grande Pueblos built the only permanent American Indian architecture north of tne Great River . . . The adobe pueblos survived and their builders "Indianized" the architecture of their conquerors . . . The Spanish were also adobe builders, the carriers of a body of knowledge that had been enriched by the addition of Moorish esthetic values and technology . . . But the labor force that executed most ideas and carried out most orders was Indian, experienced workers already familiar with their own method of earthen construction. The builders of Taos, Acoma, Santa Domingo, and other pueblos were the inheriters of firmly established usages, reinforced by custom, and these usages the Spanish were obligated to accept . . .[8]

The traditional division of labor that existed among the Indian inhabitants of Northern New Mexico passed on, in somewhat modified form to the Spanish settlers of the area. The women, both Indian and Spanish, played roles of varying importance in the construction and maintenance of adobe homes. In many cases, women built the entire structures without the participation of men and owned the homes in which families lived. In other cases, especially in later years, after the Spanish had become firmly settled in the area, the woman's responsibility decreased somewhat. But in the traditional division of labor

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[8]Anita Rodrequez, "Adobe Traditions in Northern New Mexico," Adobe News, Issue #15, pp. 20-21.

surrounding adobe construction, it was the woman who was most related to the work with the sun-dried mixed earth, the adobe:

There was a traditional division of labor among the Indians, a practice so tenacious that it has survived until the present day. Men were willing and skilled woodworkers, and they easily mastered carpentry. But it was women who were the adoberas. They were the acknowledged experts of pre-columbian adobe, and men neither would nor could do that work. And so it happened that for another 400 years women continued to be the chief builders and architects in the Southwest. Feminine history is notoriously invisible, and laborers too suffer from historical invisibility. Otherwise, it might be a better known fact that the woman builder in the Southwest is part of a continuous and unbroken tradition of some five (or more) centuries standing . . . Even today the women of the Taos Pueblo are responsible for the maintenance of the entire village -- as their female ancestors have been since they originally built it. The pueblo is completely replastered before the annual San Geronimo Fiesta; men mix the soquete and women plaster. Women own the homes in which their families live, and women still undertake to build entire houses, casually, and with a minimum of masculine help. Usually, however, women confine their construction activities to the finishing, which includes several different skills or processes . . . Among the Spanish-speaking villages of Northern New Mexico, women who specialize in adobe architecture are known as enjarradoras. As among Indian women an expert enjarradoras knows all the final phases of building -- the laying of mud floors, the building of fireplaces, hornos, interior and exterior plaster, details such as bancos, niches. She is a designer, and she must know all about repair and maintenance. This body of construction knowledge has been passed on in the oral tradition of Southwestern women, both Indian and Spanish, and nowhere else. At one time, enjarradoras was as commonplace a skill as the making of tortillas, and at least plastering

and alisando (for which no translation exists except a description of the process) were part of every woman's usual domestic knowledge . . .[9]

The use of adobe was not confined to only the Spanish settlers of the Southwest, however. Earth-wall houses were also erected by the early settlers on the Atlantic seaboard. One two-storied rammed-earth residence now in use in Washington, D.C., is said to have been built in 1773. Many other adobe structures built during the 1800's are still standing and being lived in.

Modern homes of earth-wall construction have been built since 1920 in Washington, D.C., Michigan, North Dakota, Idaho, Illinois, Arkansas, Oklahoma, Colorado, and in all of the southwestern states (including Texas). During World War II, a number of labor-relief projects made use of the adobe-brick method of construction. Projects included a city hall and library, state park buildings, county fairgrounds, buildings, airport structures, county and federal offices, and both state and federal forestry department buildings were built of adobe in the State of California. Some of these buildings have been admired as examples of the state's most beautiful architecture.

There is no doubt that, since the 1950's, adobe construction declined in most parts of the United States, except for Arizona and New Mexico.

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[9]Ibid, pp. 20-21

There is still much adobe construction in the Northern New Mexico area, particularly on Indian reservations, where in some cases the new federally-funded housing built by the U.S. Department of Housing and Urban Development is adobe. Only a small number of adobe homes are still built in California compared with other types of housing, and these are located primarily in the area of Fresno, where the largest manufacturer of the stabilized adobe brick in the United States exists. However, in recent years, with the increased concern over the rising costs of building materials and energy, a widespread interest in the use of adobe has once again emerged.

IV. ADOBE FOR SELF-HELP ECONOMIC DEVELOPMENT IN THE SOUTHWEST

"In fact, a village cannot exist by itself and should not be considered an isolated entity. At all points it should fit into the overall pattern -- not merely in space, but in the various dimensions of social and economic growth, so that as it evolves and its work, trade, and way of life develops, it will help to maintain, rather than disrupt the ecological stability of the region."

- Hasan Fathy
Architecture for the Poor

A healthy local economy, like a healthy national economy, is one in which the money derived from the sale of goods and services exceeds the money spent for goods and services outside the local economy.[10] Many local communities, attempting to revitalize the local economy in order to create employment opportunities and an expanded tax base, often undertake expensive campaigns to attract industry to their area. Elected officials ask taxpayers to support the construction of industrial parks through general obligation bonds or give up potential revenues to offer tax moratoriums to industries relocating to their jurisdiction. As Jim Seibert, a writer on the economics of adobe points out, "All these inducements are considered the minimum ante in a highly competitive industrial game, where

[10]This section draws heavily from Jim Seibert's article on "Adobe Economics" in Issue 13 of Adobe News.

an estimated 20,000 communities vie each year for approximately 500 new and relocating manufacturing plants." Unfortunately, because of these odds, the success rate for attracting new industries in most localities has been very low. Furthermore, many studies have shown that even if a local community does attract a new industry, the industry attracts more workers from outside the community than there are jobs.

The alternative to this reliance on the "capricious whims" of a highly mobile manufacturing industry is for local and regional communities to examine and utilize their own local resources and manufacturing potential -- a major tenet of the shift to more appropriate technologies. The benefits of such a course have far-reaching consequences, not only for the creation of new jobs and an expanded tax base, but also in energy conservation and the development of self-reliant local and regional communities, as will be shown later.

In the Southwest, the production of adobe blocks is one of the resources and manufacturing capabilities readily available to most communities. After manufacture, the adobe blocks are used in the construction of homes and other buildings. This benefits the local economy in the following way:

"As long as money remains within the local economy, dollars generate other dollars; the adobe builder pays the adobe block maker, who

pays the butcher, who pays the adobe builder to add an addition on his house, and so forth. On the other hand, money spent for goods and services outside the local community accrues to the benefit of another city . . . Along with the manufacturing industry, the construction industry is considered a major contribution to the local economy. If the construction industry is examined more closely, we discover that a majority of the building materials -- sheet rock, milled lumber, plywood, exterior sheathing, foam insulation, aluminum and plastics -- must ultimately be purchased from non-local sources. While the building material suppliers derive some benefit, the greatest percentage of dollar expenditures for the purchase of building materials leaves the community. In addition, the large-scale developer/builder may bring in tradesmen from outside the area. Adobe block, on the other hand, is usually manufactured locally; the builders live in the community and the dollars spent for adobe construction remain in the local economy. Because of their aesthetic compatibility, hand-carved doors, locally manufactured furniture, and other handcrafted items often accompany adobe building construction. This 'secondary effect' provides additional assistance in alleviating the problem of underemployment and unemployment; critical in rural areas . . ."[11]

Another benefit to be derived from the increased use of adobe for housing construction is the creation of new jobs and economic enterprises, based on self-help concepts, that are locally owned and operated. The new jobs created in the areas of manufacturing, transporting, and the laying of adobe can be filled with a mininum of training or by unemployed people already possessing the required skills. These employment

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[11]Jim Seibert, "Adobe Economics," Adobe News, Issue #13.

opportunities would become available in many of the most economically depressed parts of the Southwest and would easily fit into existing lifestyles. Because adobe construction is a labor-intensive process and does not require a high degree of technical proficiency, it is particularly well-suited for apprentice-type job programs for the structurally unemployed.

A study on the Feasibility of Mechanized Adobe Production[12] commissioned by the Four Corners Regional Commission and prepared by the University of New Mexico's Center for Environmental Research and Development, describes how a cooperative, self-help type adobe manufacturing operation would meet employment and training needs in poorer regions of the Southwest:

"The centers producing, transporting, and marketing adobes could be cooperatives, based upon new or existing community associations in poor regions. Such businesses could provide needed income and serve as focuses for community action, which might expand into other areas. They could also serve as training programs for developing other than labor skills: administrative, managerial, promotional, and merchandizing skills. People who truely wanted to develop these kinds of talents, marketable in the larger consumer-oriented society of the region and country, could do so within their own surroundings and their own way of living without having to migrate to urban areas foreign and maybe hostile to them."[13]

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[12]Four Corners Regional Commission, A Study of the Feasibility of Mechanized Adobe Production (Center for Environmental Research and Development: 1970-1973).

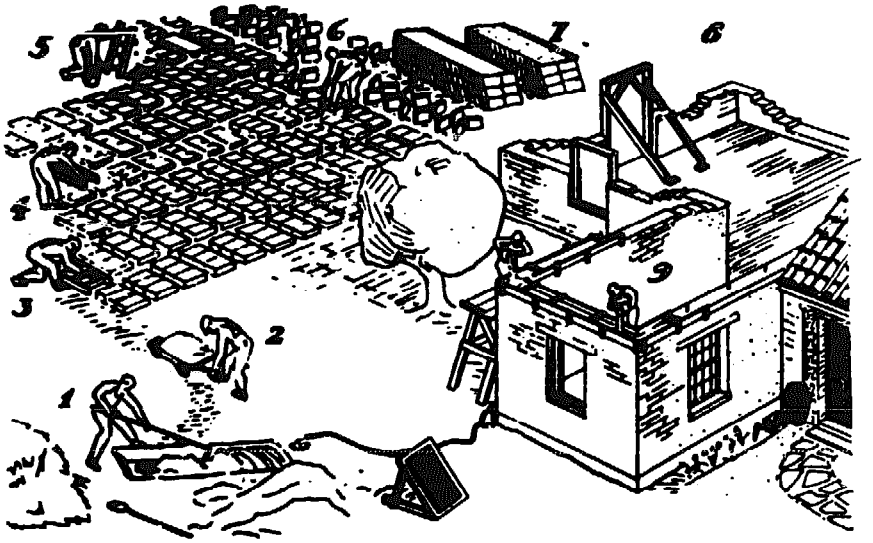
[13]Ibid., p. 3.

As mentioned above, adobe is particularly well adapted for self-help types of enterprises because adobe does not require complex technical skills and is labor-intensive (see exhibit on next page). Adobe wall construction in certain respects requires a lower level of skill than woodframe construction. It is a skill that still exists in the Southwest and is a familiar way of building in many areas.

There is a move in federal low-income housing assistance toward the "sweat-equity" concept, and a large supply of cheap adobe brick can offer more people a chance to gain a proportionately larger sweat equity in self-help housing. This idea has been realized and made into a reality by the many persons who have become "owner-builders" -- persons who build their own homes. Especially in the Southwest and in parts of California, there is a growing familiarity with the realities of home construction using native materials, particularly adobe, which are readily at hand. Peter Dresser notes in his book, Homegrown Sundwellings,[14] that, "There are many communities within which the building of a house is still very much a family affair, with several generations participating in the mixing and laying of adobe, the hauling in, barking and placing of vigas, and all the other steps in creating a habitation literally from the ground

[14]Peter Van Dresser, Homegrown Sundwellings (Lightening Tree Press: 1977).

STEPS IN THE ADOBE BUILDING PROCESS



COMPOSITE SKETCH OF THE STEPS IN ADOBE CONSTRUCTION. THE SOIL, WATER, STRAW, AND ANY OTHER ADMIXTURES ARE THOROUGHLY MIXED TO A STIFF MUD CONSISTENCY (1). THIS IS CARRIED TO A SMOOTH, LEVEL AREA (2), AND MOLDED INTO BRICK (3). THE FORM IS REMOVED IMMEDIATELY (4), AND THE INSIDE SURFACES WASHED WITH A WET RAG (5). IN NORMAL DRYING WEATHER THE BRICKS ARE TURNED ON EDGE THE SECOND OR THIRD DAY TO DRY EVENLY FROM BOTH FACES (6), AND WITHIN A WEEK ARE STACKED IN PILES TO CURE (7). WITHIN ANOTHER WEEK OR SO THEY MAY BE LAID IN THE WALL, USING MUD MORTAR AND STARTING THE COURSES AT CORNERS, INTERSECTIONS, AND OPENINGS (8). A REINFORCED CONCRETE COLLAR BEAM OR BOND STONE POURED CONTINUOUSLY AROUND THE TOPS OF ALL WALLS AND AT EACH FLOOR LEVEL PROVIDES AN EXCELLENT ATTACHMENT FOR THE ROOF AND FLOOR SYSTEMS, AND STRENGTHENS THE WALLS AGAINST LATERAL STRESSES (9). (FROM ADOBE CONSTRUCTION, BULLETIN 472, CALIFORNIA AGRICULTURAL EXPERIMENT STATION, UNIVERSITY OF CALIFORNIA, BERKELEY, COLLEGE OF AGRICULTURE, WRITTEN BY J.D. LONG AND REVISED BY L.W. NUEBAUER IN NOVEMBER, 1946.)

up. And this familiarity is being generously shared with new settlers in the region, many of whom have become skilled craftsmen and small building contractors in their own right. This is an ideal situation for the nurturing and diffusion of an effective latter-day folk technology in solar utilization . . . its grassroots practitioners have already pioneered valuable pilot experiments in the field, and as a result, New Mexico now has an international reputation for this kind of pioneering."[15]

One indication of the popularity of adobe among energy-conscious owner-builders in the Southwest is the fact that seven out of every ten owner-built homes equiped with solar heating in the Albuquerque area is an adobe. Prospective home builders, especially those with few financial resources, are taking a fresh look at alternative building skills and considering how ancient building methods may combine with newer solar applications to bring about a bio-regional architecture that is in tune with its environment and much lower in cost to build and maintain. Because of the escalating building and utility costs associated with the growing scarcity of imported high-technology materials that are capital-intensive and resource depleting, it is time that government agencies concerned with providing for low-cost housing and economic development of poor regions also begin to seriously consider similar alternatives.

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[15] Ibid, pp. 79-80.

V. ADOBE FOR ENERGY AND RESOURCE CONSERVATION IN THE SOUTHWEST

Building materials and energy conservation must be looked at from the comprehensive perspective: where a material is, how long before it is depleted, how far it must be transported, how much it must be processed, whether that process pollutes, and whether people can make use of it directly for their own use are some of the more important considerations to keep in mind from the appropriate technology perspective. It is also obvious that most of the processes required to deliver various sources of energy and resources for conserving energy can be highly wasteful activities themselves.

When seen in this light, adobe emerges as a truely energy-conserving building material for the Southwest, especially when it is equiped with a passive solar heating system, for which it is remarkably well-adapted. This type of building is known as the "solar-adobe." Adobe, as a building material for the Southwest at least, is a low energy-intensive material, requiring little or no transportation, nor any need for manufacturing processing. In other words, little energy is expended to produce the material and transport it to the building site. Indeed, adobe can be produced directly on the building site, if desired. Adobe construction is known for its use of local materials that do not pollute the environment during manufacture and do not use large amounts of fuel

to be moved from the point of their manufacture to place of use. Contrast this situation with that of woodframe construction, which depletes the available reserve of our timber resources (forests), requires energy-intensive manufacturing processing to make it ready for use, and then requires the use of fuel and capital-intensive methods of transport to move it over long distances to the building construction site. It is no wonder that builders are paying as much as $400 for 1,000 feet of lumber that cost only $100 ten years ago.[16]

For much the same reasons, even certain "energy-conserving" materials, such as polystyrene and other petroleum-based products used for insulating walls, are not true energy-conservers. Many of the petroleum-based insulators pollute at the point of manufacture, and they require more energy to produce and transport to southwestern markets. Furthermore, they are constantly rising in price, and there is no guarantee that they will be available indefinitely.[17] The most energy-conscious of the southwestern builders will attempt to keep to a minimum the use of synthetic, imported materials, and use native materials and passive solar energy. In doing so, they conserve energy, while at the same

[16] Time (September 12, 1977)

[17] Adobe News, Issue #18, p.22

time satisfying their aesthetic, cultural, and design requirements and tastes. Unfortunately, most discussion regarding energy conservation has been limited to short-term measurements of energy-efficiency instead of long-term energy costs of the total manufacturing, transportation, and construction process.

In order to determine how energy-conserving a structure is once it has been built, a large amount of attention has been devoted to measuring the thermal performances of various types of building materials. Energy conservation codes have been devised to set standards for different types of walls to require minimum degrees of insulation from outside temperature fluctuations, thereby reducing heating or cooling costs and reliance on expensive, energy-draining and capital-intensive machinery (such as heating and air conditioning systems) to create comfortable indoor temperatures.

There are several properties of building materials that determine the "insulating power" of a wall, i.e., the material's ability to prevent heat from passing through it. These properties are called the "thermal conductivity" and "thermal diffusivity" of a wall. The thermal conductivity and diffusivity of a wall are merely properties which affect the heat transfer rate of a wall (heat passing through a wall) built of various different types of building materials. The measurements used to describe the thermal

performances of a particular building material are called the "R" and "U" values. The measurement commonly known as the "R" value is simply the figure which gives the "insulating power" of a wall, or the wall's resistance to outside temperature fluctuations. The "R" value is arrived at by dividing the thickness of the wall by the wall's thermal conductivity; thermal conductivity being an expression of how fast heat passes through the wall. The U value equals the reciprocal of the total resistance of the wall.[18]

Since our discussion concerns the transfer of heat (heat loss or gain) through a wall, a short explanation of the primary source of this heat, or thermal energy, is in order and will help to explain what follows when we discuss the thermal performance of adobe walls. Solar energy, heat from the sun, is obviously the primary source of heat and the major determinant of outside temperature fluctuations. Because of this, the important factor in whether thermal energy reaches and is stored in a wall is the wall's orientation to the sun for passive solar gain. Simply, a house facing the sun will absorb thermal energy from the sun, and this energy is "stored" for a certain period of time

[18]H. Alan Fine, "Thermal Properties of Building Materials," Adobe News, Issue #11, p. 26.

in the walls of the house. Basically, this is the concept behind the use of passive solar energy systems to heat homes.[19]

Now adobe walls have never been considered good insulators by many conventional builders, and researchers in this area have attempted for years to determine why adobe homes were still regarded by most of their occupants as very comfortable, particularly in regions with extreme temperature fluctuations. Adobe builders had long felt shortchanged by the use of the steady state R and U values to measure energy use in an adobe structure. The answer lies in the way the adobe absorbs and stores the thermal energy of the sun in its massive walls, and a new U value, called the "effective U value" was devised by University of New Mexico to measure this dynamic thermal performance of adobe. The concept is merely a recognition on the part of the scientific community of a process which earlier native users

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[19]Passive solar energy systems use natural forms of heat transfer, as opposed to active systems which use some other energy source to move thermal energy from points of collection to points of storage or distribution. Both kinds of systems have been designed to utilize the sun's energy for home heating and cooling, as well as domestic hot water supplies. Since, according to the most reliable estimates, about 70% of one's total household energy needs will be used for either home heating and water heating, the use of solar energy for these needs can considerably reduce the utility costs associated with these needs.

of adobe had known forthousands of years. H. Alan Fine, in a short article, describes the concept behind the effective U value:

> Only after a few seconds, minutes, or even hours does heat begin to flow at a rather steady state from the high to the low temperature side (or from the outside of a wall to the inside, during the day). It is only after this steady condition has been attained that the total resistance of the wall can be used to calculate how much heat is entering or leaving through the wall . . . The wall must attain its capacity of heat before heat will flow through the wall at a steady rate. The higher the capacity of the wall, the longer it will take for steady heat flow to occur.[20]

Because of the large heat capacity (thermal mass of the thick walls) of adobe, it takes some time for heat to begin passing through the adobe wall at a steady rate during the hot day, which has the effect of maintaining a cooler temperature inside the adobe home during this period. Toward the evening, however, the adobe wall has reached its heat capacity and the heat stored in the wall begins to flow into the inside of the house at a steady rate. This keeps the inside of the adobe home warm during the cooler evenings. Because this process is a cyclical one that is repeated each day and night, it is probably the most interesting example of a wholly natural heating and cooling system -- an interaction between sun and natural earth to provide comfortable

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[20] Ibid., p. 14

habitation for human beings. This cost-free system was known to other cultures, in addition to the southwestern native peoples.

" . . . The traditional architecture of many cultures in climates where the temperatures are uncomfortably hot during the day and uncomfortably cool at night features buildings with thick walls of brick or stone. Such walls are both insulators and reservoirs of heat, so that during the hotter hours of the day the flow of heat from the external environment to the internal one is retarded, and during the cooler hours part of the heat stored in the walls warms the internal environment, and the rest is lost to the external one. The net result is a flattening of the temperature-variation curve inside the building . . . They demonstrate the possibilities of working with rather than against the external environment . . . and consume minimal amounts of energy."[21]

There are very ancient traditions of passive solar architecture with roots dating back to prehistory and into many different cultures. These traditions used appropriate siting of a building, orientation of the building toward the sun, design geometry, and the careful selection of certain indigenous building materials, such as adobe, to take full advantage of passive solar gain -- thermal energy -- to heat or cool their homes. A very long time ago, the native peoples of this continent produced numerous excellent examples of this intelligent siting, with real

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[21]Passive Cooling Systems in Iranian Architecture," by Mendi N. Bahadori, in Scientific American (February 1979).

concern for the forces of nature and an understanding of the building materials available to them: "The community of Mesa Verde, Colorado is one of the many that could be used to illustrate this exceptional awareness and skill. Massive stone buildings are clustered under a cliff which protects them from the heat of the summer sun, night sky cooling, and winter winds, while providing great thermal mass to temper the environment . . . Chaco Canyon, New Mexico is another early example of what may be called passive solar design. A thriving civilization existed there over a thousand years ago with stone buildings which rose to five stories in a curious and practical geometry. They flung out their arms to embrace the sun, with walls of massive masonry for thermal storage. The buildings were terraced and the roofs of each succeeding unit provided a space outdoors to live and work in contact with nature. All day the sun's heat was buried in these massive walls, and in the great cliff to the north, which also protected them from winter winds."[22]

[22]"Solar Energy Short-Course," New Mexico Solar Energy Association, 1977.

VI. RECENT DEVELOPMENT OF ADOBE AS AN APPROPRIATE TECHNOLOGY

We will now examine the recent development of adobe in the Southwest states and describe, in some detail, an example of a model research and demonstration project -- the Homegrown Sundwellings Project -- that incorporates in its design and operation every characteristic of what utilizing adobe as a socially appropriate technology should achieve in both theory and practice. There are many adobe research and development projects currently in progress. Most of them cannot be mentioned here due to the lack of space.

For California, there is some hope that the climate for adobe construction may improve. Recently, the California Department of Housing and Community Development began considering more permissive regulations for what they term "alternate" building materials. The challenge in California is to discover ways to build earthquake resistant masonry without high cost. The adobe mission builders designed with massive buttresses and thick walls. Now most local building codes, especially in dangerous seismic safety zones, require buildings made with materials such as adobe to include costly steel reinforcement. Adobe builders claim that adobe will withstand earthquakes if adequate footings, bond beams and ties are built in.

Dr. Karl Schultz of California believes he has found a new way to give structurally weak adobe enough strength to meet stringent local building codes. He began experimenting with reinforced adobe over ten years ago and has found a method which utilizes a wire framework on which the adobe mud would be blown. Because of his work and the increasing interest in adobe again in the Northern California area, he and others recently formed the Adobe Association of Northern California. The group has obtained a building site from the County of Alameda and is beginning experimental construction. They hope to start a revival of adobe construction in the area within the next few years. This area of California may once again see modern adobe homes built here as they were decades ago.

The Farmers Home Administration has been ordered to draw up relatively simple guidelines for the financing of homes built with adobe by the Assistant Secretary of Agriculture for Rural Development, Alex Mercure. The new directive has no bearing on FHA financing, but it does open the door at the Federal level for adobe construction through FHA, according to Adobe News. Mercure seems committed to the possibility for greater use of adobe and said, "Adobe has been in and out of favor with federal housing programs, but it's time to demonstrate FHA's commitment to the use of adobe as well as other less conventional materials which are cost effective." He agreed that adobe is efficient both in winter and summer and that adobe would

meet a need for "flexibility in our programs to respond to local problems rather than attempt, as we have in the past, to impose national standards and solutions for dissimilar local problems and needs."

Mercure also focused on what is becoming a reality for the people who have to build their own homes because they are becoming too expensive to buy. He agrees that adobe will meet a need for low and moderate income families who may choose a self-help process to satisfy a desire for home ownership. Local FHA officials in New Mexico have already begun to finance adobe construction.

At the present time, the State of New Mexico, especially the northern region of the state around Santa Fe, is the leader in developing the art of adobe construction and other alternative socially appropriate technologies, such as passive solar energy systems for small-scale use. This situation occurred partly because adobe has historically been the traditional building material in this region, with the City of Santa Fe being nationally recognized as the center of this tradition in the United States. In addition, local building and energy-conservation codes in the region favored the use of adobe as a building material for new construction, in contrast with other states and localities. Because New Mexico is not an earth-quake zone, there are no seismic safety requirements that have the effect of either prohibiting construction with adobe entirely

or necessitating the use of costly steel reinforcement. In fact, adobe brick manufacturers in the area cannot meet the huge demand for adobes. There are, however, obstacles to the use of adobe even in New Mexico. This is particularly true for Federally-funded adobe construction where inappropriate classification systems under the Department of Labor's Davis-Bacon regulations and overly stringent building regulations for adobe under the Department of Housing and Urban Development's Minimum Property Standards drive up the cost of adobe construction to levels endangering further federally-funded adobe construction.

Overall, though, the outlook for increased use of adobe in New Mexico looks very favorable and has been given strong encouragement by the recent completion of the Ghost Ranch Sundwellings Project. The Sundwellings program was begun in mid-1974 by the Four Corners Regional Commission and was conceived as a means of "working with and strengthening the grassroots movement in New Mexico towards self-help solutions to the mounting problems of shelter, energy, and food shortages. Intelligent use of universally available natural resources (mainly sun, earth, and timber), and of the traditional skills of the citizenry, were the keynotes of this movement." The entire project, from start to finish, was a model of appropriate technology in action. Funding for the project came from various sources. The Four Corners Regional Commission

sponsored materials and consulting monies. Training and labor funds were provided by the New Mexico Governor's Office of Employment and Training, the Employment Security Commission, and the All Indian Pueblo Council CETA program. The Los Alamos Scientific Laboratory provided instruments for monitoring the thermal performance of the buildings. The building site for the demonstration buildings was the Ghost Ranch Conference Center near Abiquiu in the Chama Valley sector of Rio Arriba County. It was chosen because it "was a non-profit institution situated in the heart of the extensive Northern New Mexico uplands region where the tradition of self-sufficiency and basic livelihood skills is strong, and because Ranch staff had considerable experience in administering cooperative programs with local people in such fields as ranch management, animal husbandry, craft training, and village development.[23]

The Sundwellings Project, over a two-year period, succeeded in constructing four adobe buildings identical in size, orientation, and construction materials at a total cost of under $100,000. Three of the adobe buildings were equipped with passive solar energy systems (direct gain, trombe wall, and solar greenhouse), while the fourth unit has no passive solar energy system installed and served as a control unit.

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[23]Peter Van Dresser, Homegrown Sundwellings (Lightening Tree Press: 1977), p. 13

The actual process of constructing the four buildings was carried out using only indigenous, low-energy materials. Stone was used on two buildings for stem walls. Adobe bricks were made on the building site itself. Vigas (supporting wood poles) were cut in a nearby forest. Doors, window units, and the domestic hot water collectors were all fabricated on site. Rough sawn lumber, milled locally, was used for the decking and framing. Insulation values equal to fiberglass and polystyrene were achieved with pumice and sawdust.

In addition to the work of the team of engineer-physicists, architects, and solar researchers and experimenters -- most with long-term concerns in the field and a personal familiarity with life and livelihood in rural and village New Mexico -- twenty young citizens of the region assisted in the construction of the four buildings and were trained in the practice and theory of energy-conserving solar-adobe construction through a program especially designed for this purpose, called the Solar Housing Construction Training Program. These trainees, many of whom would otherwise still be unemployed, spent six hours per day on the worksite learning by actual practice the methods of adobe construction and passive solar energy systems, and two hours in the classroom each day for theoretical instruction over a four-month period. The classroom training covered three major areas: adobe construction, passive solar systems, and contracting/design skills. Guest

instructors (many leaders in their field) and on-the-job training supplemented the instruction. The graduates completed the coursework in July of 1976 and received a Solar Construction Technician/Craftsman certificate. With minimal practical experience, these graduates will be able to do their own contracting. Several students are expected to emerge as designers/ builders of solar adobe homes within the next few years. Most graduates have found good jobs already.

Because the construction of the Sundwellings was also designed to serve as a research and demonstration project for the region, these units upon completion have served many functions. The Los Alamos Scientific Laboratory is testing the thermal performance of the four buildings. About fifty thermo-couples have been installed in each unit. An on-site weather station and sixteen point recorders are presently collecting data on the units. Just as important to the success of the Sundwellings Project is the use of the buildings to demonstrate in practice the viability of building low-cost, energy-efficient solar adobes to the wider population of the region and the nation. Standing as a demonstration center for the area, people will be able to see the systems in use. One way this is being accomplished is through the use of the buildings as live-in quarters for the guests at various conferences and events sponsored by the Ghost Ranch Conference Center, where the units are located. The Homegrown Sundwellings concept will

thus be an acutal experience of various groups of people who obtain an opportunity to visit them or actually live in them. As explained by Jeffrey Cook, of Arizona State University's College of Architecture, the Sundwellings concept goes beyond energy conservation and other purely economic concerns toward the statement of a new ethic and the expression of a complete lifestyle. (also see exhibit on next page)

The Homegrown Sundwellings concept takes these concerns beyond the range of comfort and costs to an ethical issue. To construct using renewable resources is not a sentimental fad in an area without exportable products to pay for imports. To build and live in accord with nature in a region considered economically underdeveloped is not wistful romanticism but a question of the style of survival. In a low cash economy it is the interactions of human resources with the immediate materials of the land that provide for the richness and fullness of life. Sundwellings are not just thermally efficient building shells. They are the comprehensive expression of a complete way of life.[24]

The Sundwellings Project would not have been possible, especially at such a low cost, without the voluntary assistance and direction of the designers, architects, and builders who are the pioneers of the movement in New Mexico towards self-help cooperative endeavors in low cost housing construction, resources conservation, and non-exploitive living techniques. Among the many persons who contributed their ideas and skills to

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[24] Ibid, p. 10.

CHANGING ATTITUDES TOWARD COMMUNITY LIFESTYLE AND THE NATURAL ENVIRONMENT

ACCORDING TO A RECENT HARRIS SURVEY, THE AMERICAN PUBLIC IS BEGINNING TO QUESTION THE WISDOM OF TOO MUCH ECONOMIC GROWTH AND CONSUMPTION: BY 79 TO 17%, AMERICANS PLACE GREATER EMPHASIS ON "HOW TO LIVE MORE WITH BASIC ESSENTIALS" THAN ON "REACHING HIGHER STANDARDS OF LIVING"; BY 76 TO 17%, PEOPLE CHOOSE "LEARNING TO GET OUR PLEASURE OUT OF NON-MATERIAL EXPERIENCES" OVER "SATISFYING OUR NEEDS FOR MORE GOODS AND SERVICES"; BY 59 TO 33%, PEOPLE DECIDED "PUTTING REAL EFFORT INTO AVOIDING THOSE THINGS THAT CAUSE POLLUTION" WAS BETTER THAN "FINDING WAYS TO CLEAN UP THE ENVIORNMENT AS THE ECONOMY EXPANDS"; AND, BY 66 TO 22%, AMERICANS ACCEPTED THE IDEA OF "BREAKING UP BIG THINGS AND GETTING BACK TO MORE HUMANIZED LIVING," RATHER THAN "DEVELOPING BIGGER AND MORE EFFICIENT WAYS OF DOING THINGS."

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make the project a success were Peter Dresser and David Wright. Peter Dresser coordinated the project and wrote the book Homegrown Sundwellings, wherein the method for solar-adobe construction is described for the general reader in easily understood language. Dresser built one of the first domestic solar water heaters in the United States in Florida during the 1940's and 1950's. Much of the theoretical foundation for the Sundwellings concept can be found in his book, A Landscape for Humans[25] and in the now famous essay by E. F. Schumaker, Small is Beautiful: Economics As If People Mattered.[26] The architect David Wright, who assisted in the design of the solar adobe buildings for the Sundwellings Project, has been nationally recognized as a forerunner in the movement for an environmental/ earthen architecture in tune with surrounding bio-regions. These persons, along with the many others like them, are applying the principles of socially appropriate technology to practical applications which suggest solutions for our national energy crisis and economic conditions, in addition to protecting the land, air, and water from industrial pollution, and other misuses of modern technology.

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[25]Peter Van Dresser, A Landscape for Humans (Biotechnic Press: 1972).

[26]E. F. Schumaker, Small is Beautiful: Economics As If People Mattered (Harper and Row: 1972).

We can be optimistic about our future social and environmental prospects in the light of the emerging breakthrough in the development of truely non-exploitive, ecologically adapted economies and lifestyles at the grassroots level. The Sundwellings Project itself should serve as national model for low-cost, energy and resource conserving housing in the United States. Solar adobe habitats in harmony with the natural environment also point the way to a simpler, and yet more enriching, lifestyle for us all.

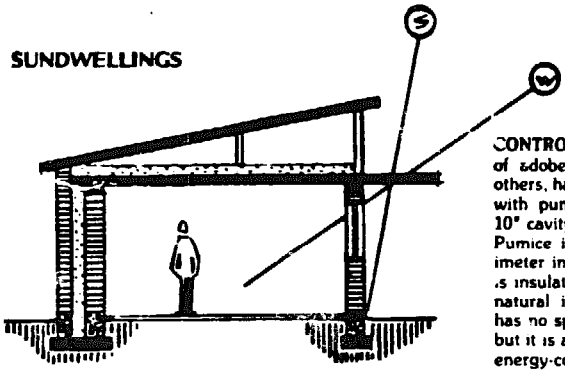
APPENDIX:

DESIGN OF HOMEGROWN SUNDWELLINGS

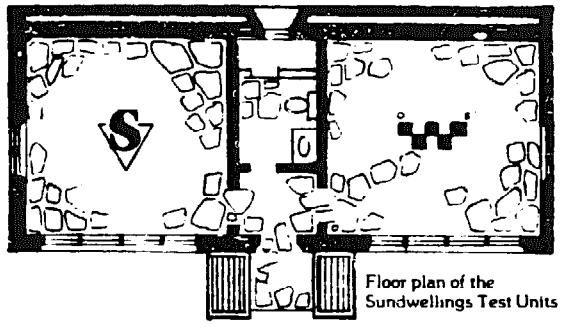
SOLAR-ADOBES*

*Peter Van Dresser, Homegrown Sundwellings. Santa Fe: Lightening Tree Press, 1977.

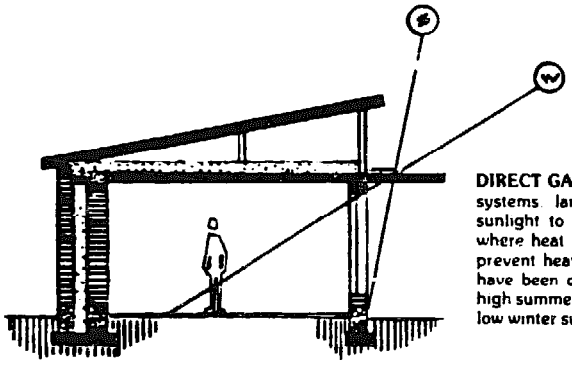
SUNDWELLINGS



CONTROL UNIT: Constructed of adobe, this unit, and all others, has a double north wall with pumice insulation in a 10" cavity to retard heat loss. Pumice is also used for perimeter insulation. The ceiling is insulated with 10 inches of natural insulation. This unit has no special solar features, but it is a good example of an energy-conserving building.

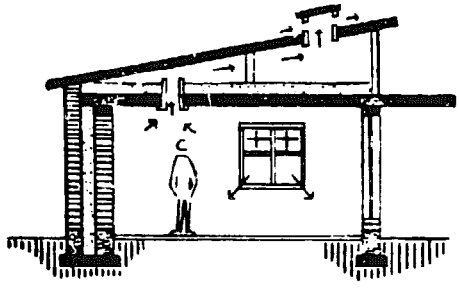


Floor plan of the Sundwellings Test Units

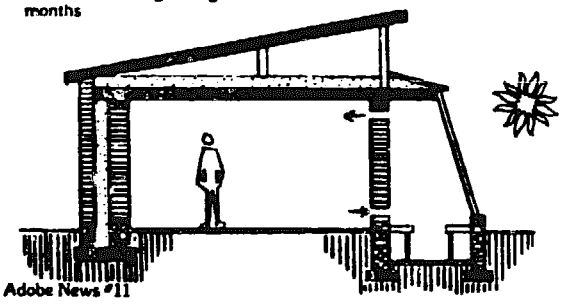


DIRECT GAIN UNIT: The simplest of systems, large south windows allow sunlight to flood the floor and walls where heat is stored. Heavy curtains prevent heat loss at night. The eaves have been designed to block out the high summer sun but allow the wanted low winter sun to flood the rooms.

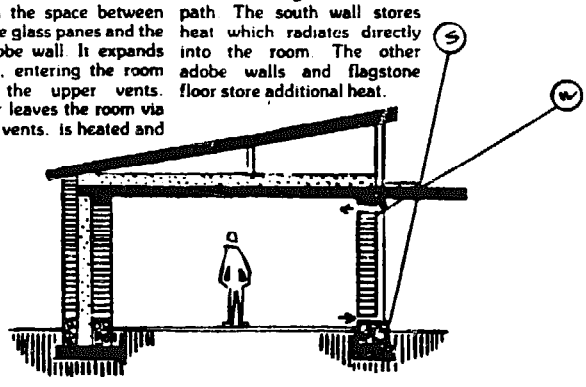
PASSIVE COOLING: The hot space between the roof and the insulated ceiling heats the air at the top of the roof, causing it to expand and rise, going outside. The large vents drawing warm air thru the ceiling vents causes a gentle cooling breeze inside the room even when the outside air is calm.

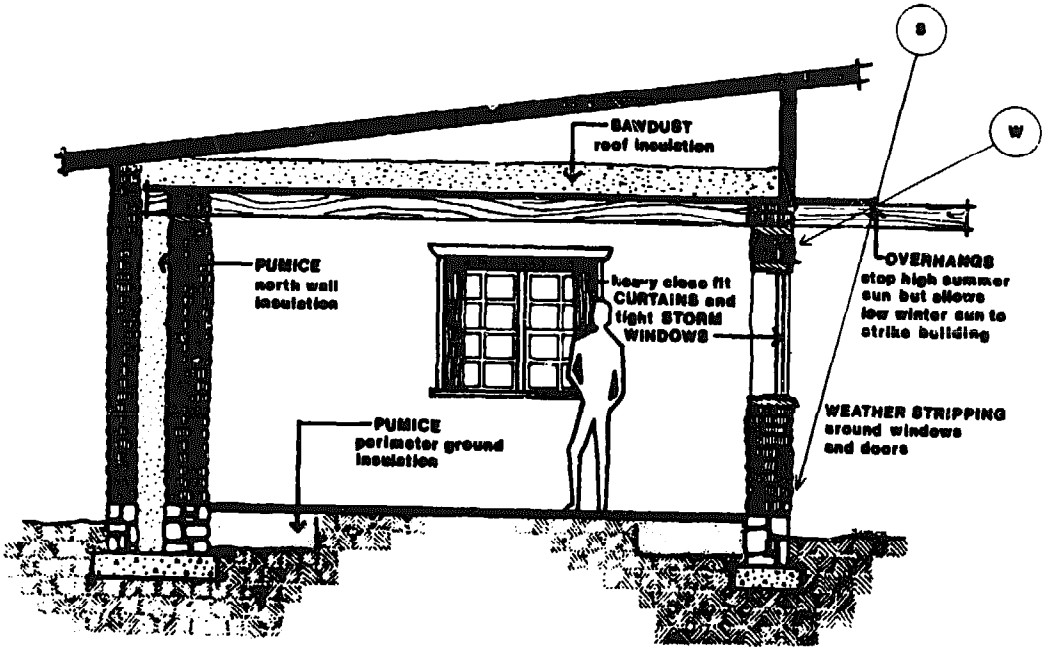


GREENHOUSE UNIT: Warm air from the greenhouse rises into the room while cool room air sinks into the greenhouse to be heated. Heat is stored overnight in the walls and floor of the room. The greenhouse is dug 2½ feet down into the ground to increase frost protection. The room can be closed off from the greenhouse to prevent unwanted heat loss or gain. The Northern New Mexico growing season can thus be extended from 4 months to 10 months.

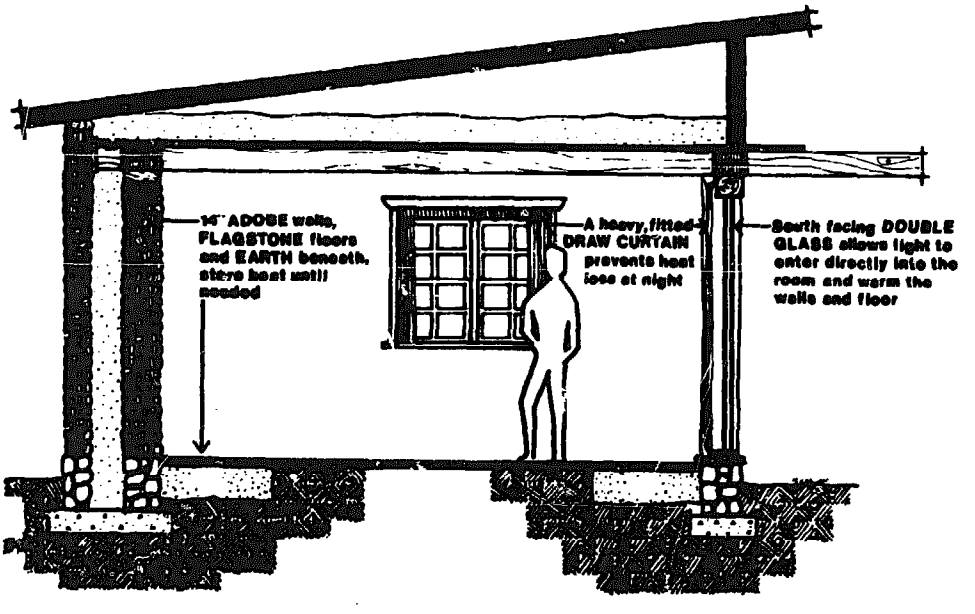


TROMBE WALL UNIT: Air is heated in the space between the double glass panes and the south adobe wall. It expands and rises, entering the room through the upper vents. Cooler air leaves the room via the lower vents. Is heated and rises, creating a circulation path. The south wall stores heat which radiates directly into the room. The other adobe walls and flagstone floor store additional heat.

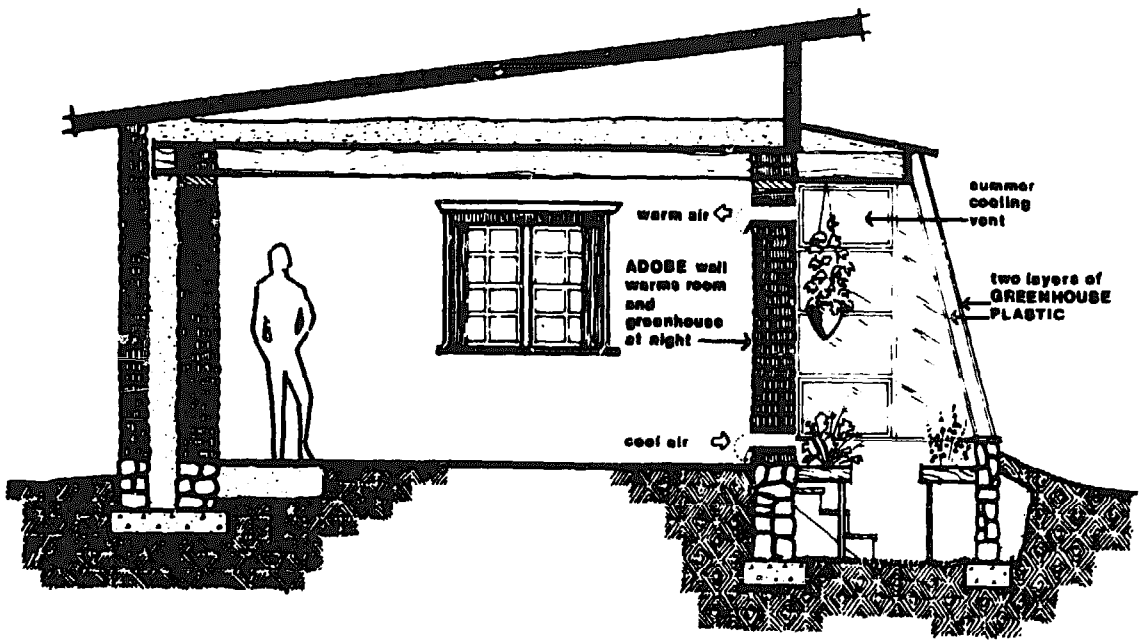




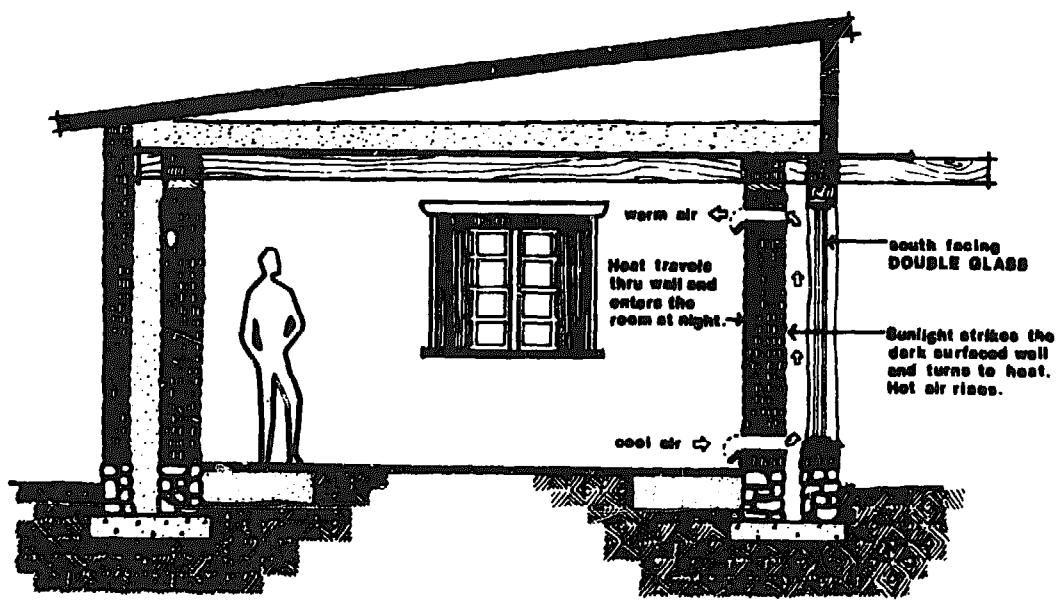
Control



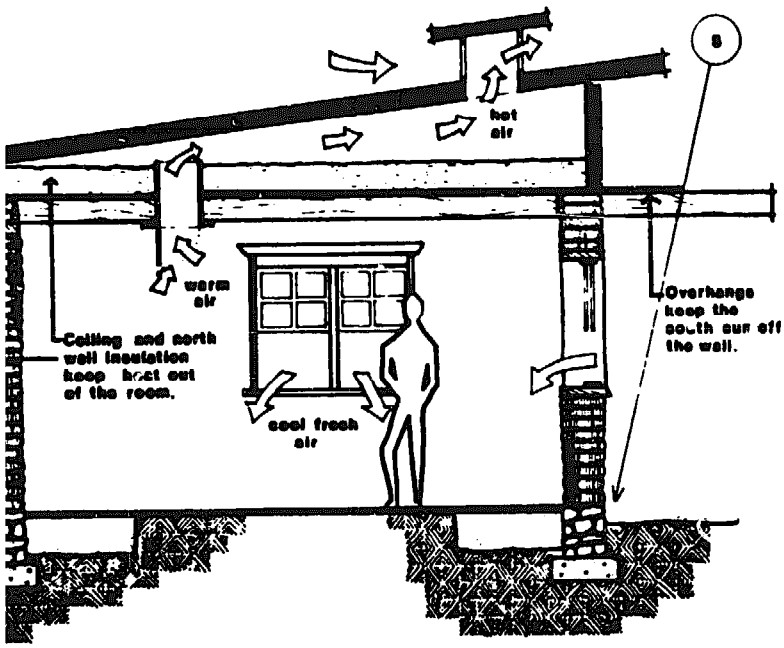
Direct Gain



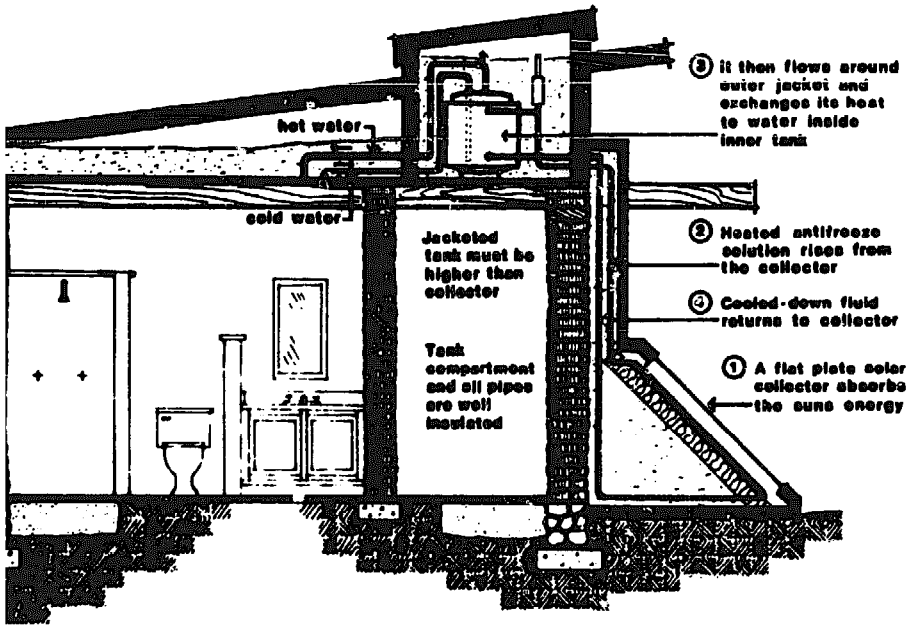
Greenhouse



Trombe Wall



Summer Comfort



Water Heating

John Timothy Mackey is a graduate of the California State University, Sonoma, where he received his B.A, with Honors, and M.P.A. degree. He has been associated with the Institute of Social and Political Research at the University of Michigan and the Institute for Applied Policy Research at California State University, Sonoma. For one year, he worked with the Office of the City Manager in Santa Rosa, directing a study of the social impacts of rapid city growth and land use, and working with local community development organizations. Currently, he is with the Office of Program Planning and Evaluation in the San Francisco Regional Office of the U.S. Department of Housing and Urban Development, where he has been researching and writing studies on housing and community development programs. The material for this article was compiled while evaluating proposed adobe research for HUD's Office of Indian Programs. During this time, the author traveled to Northern New Mexico and interviewed those persons associated with the Homegrown Sundwellings project, After which he contributed to a recent article on adobe in the Wall Street Journal.