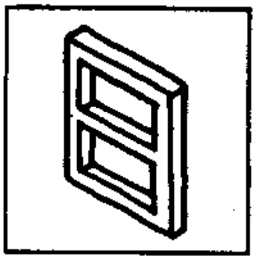
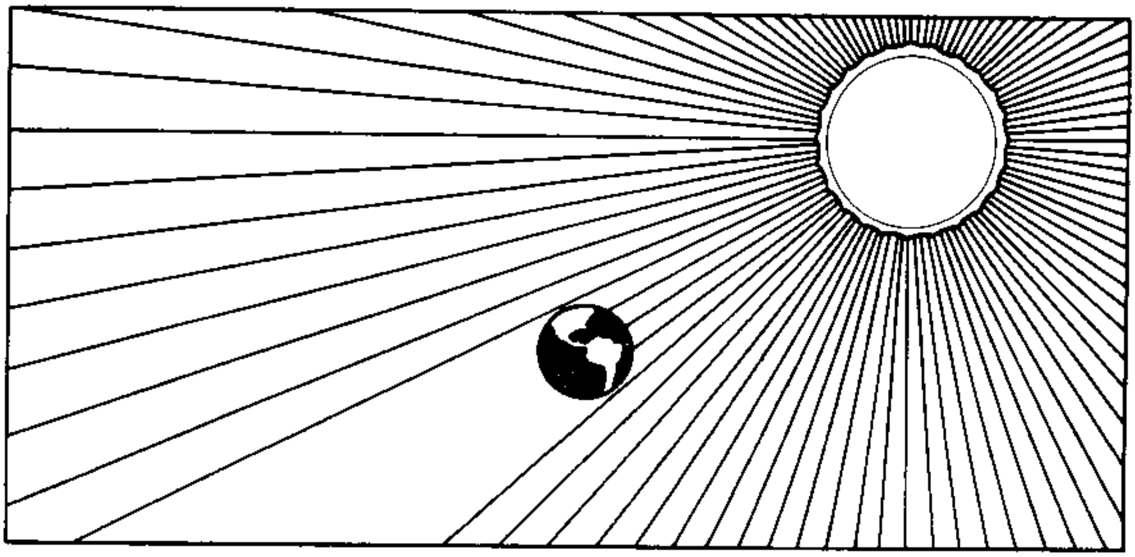
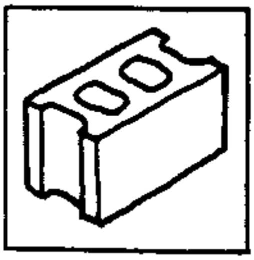
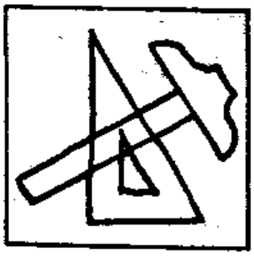
Path to Passive



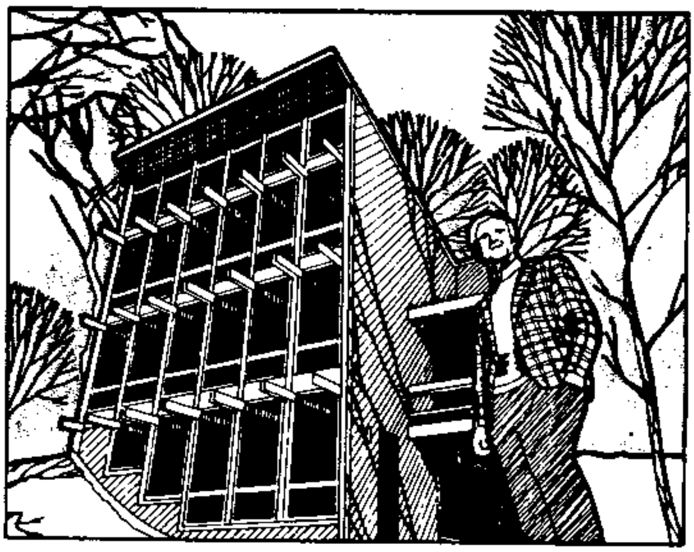




Nebraska's Passive Solar Primer



by
Solar
Energy
Associates



Path to Passive

Nebraska's Passive Solar Primer

by Solar Energy Associates, Ltd.
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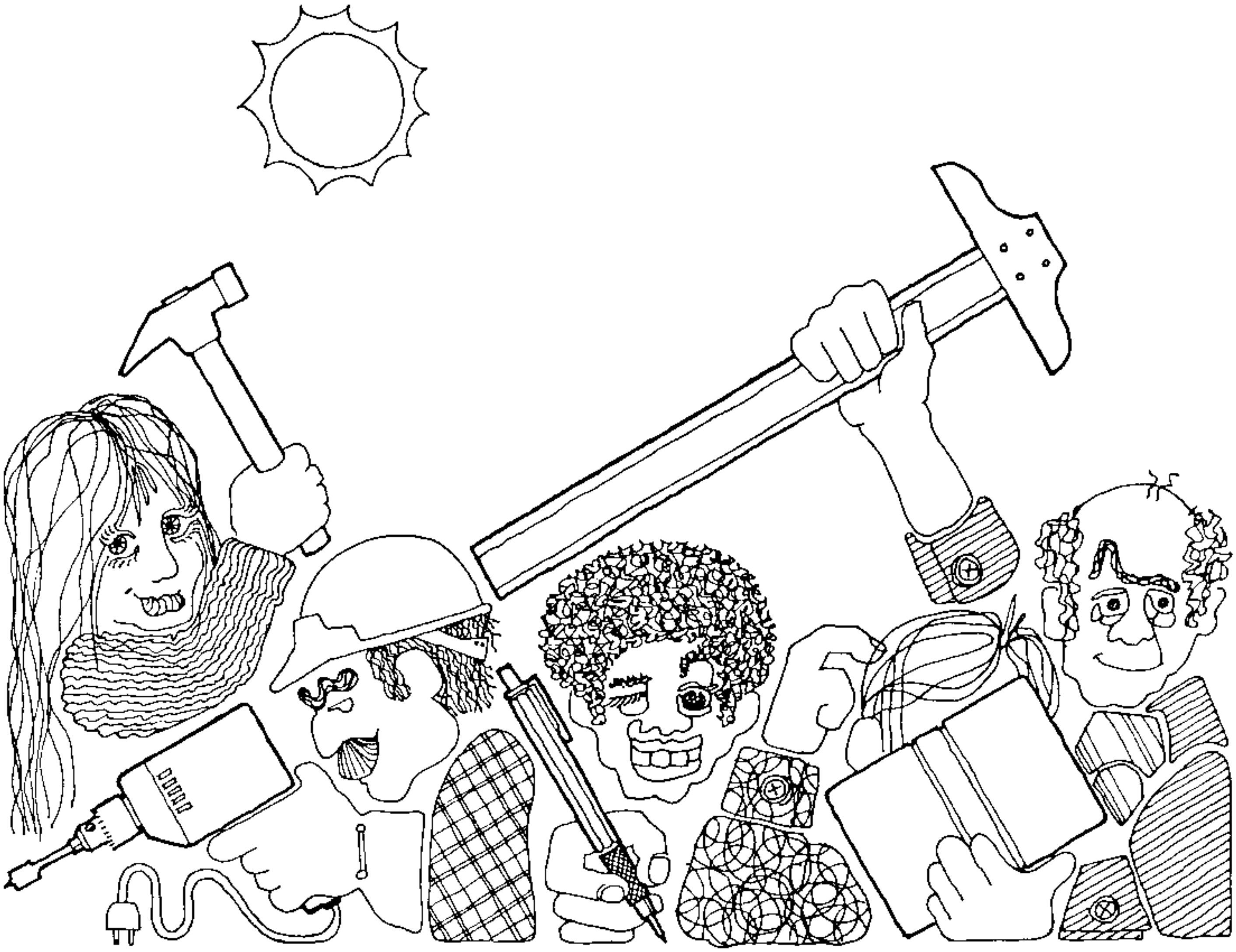
"Destiny is not a matter of chance,
it is a matter of choice;
it is not a thing to be waited for,
it is a thing to be achieved."

William Jennings Bryan

NEBRASKA'S PASSIVE SOLAR PRIMER IS A TESTAMENT TO THE DEDICATION AND EFFORT OF A SMALL BAND OF FACULTY AND STUDENTS FROM THE UNIVERSITY OF NEBRASKA. KNOWN COLLECTIVELY AS THE PASSIVE SOLAR RESEARCH GROUP (PSRG), THEY HAD A VISION OF THE FUTURE AND THE ROLE THAT PASSIVE SOLAR ENERGY COULD PLAY IN RESHAPING IT. TO THE PAST AND PRESENT MEMBERS OF THE PASSIVE SOLAR RESEARCH GROUP, IS THIS BOOK DEDICATED.



A BOOK FOR THE ARCHITECT, ENGINEER, BUILDER-CONTRACTOR AND THE HOMEOWNER

HOW TO USE THIS BOOK

The purpose of this Primer is to provide the reader with information required to make a decision on an important issue: whether or not to build an energy efficient passive solar heated home. As fossil fuel energy becomes more scarce and costly, the number of energy source options available to a homebuilder becomes limited as far as the conventional sources of energy are concerned. However, the possible variations for energy conservation and passive solar energy techniques are limited only by the imagination of the homebuilder. The Primer should be used as an introductory guide to stimulate new ideas and to avoid pitfalls which have been common to this newly emerging field. The Primer should not be regarded as the final treatise. It will undergo revisions and evolve as new knowledge enters the mainstream of passive solar energy.

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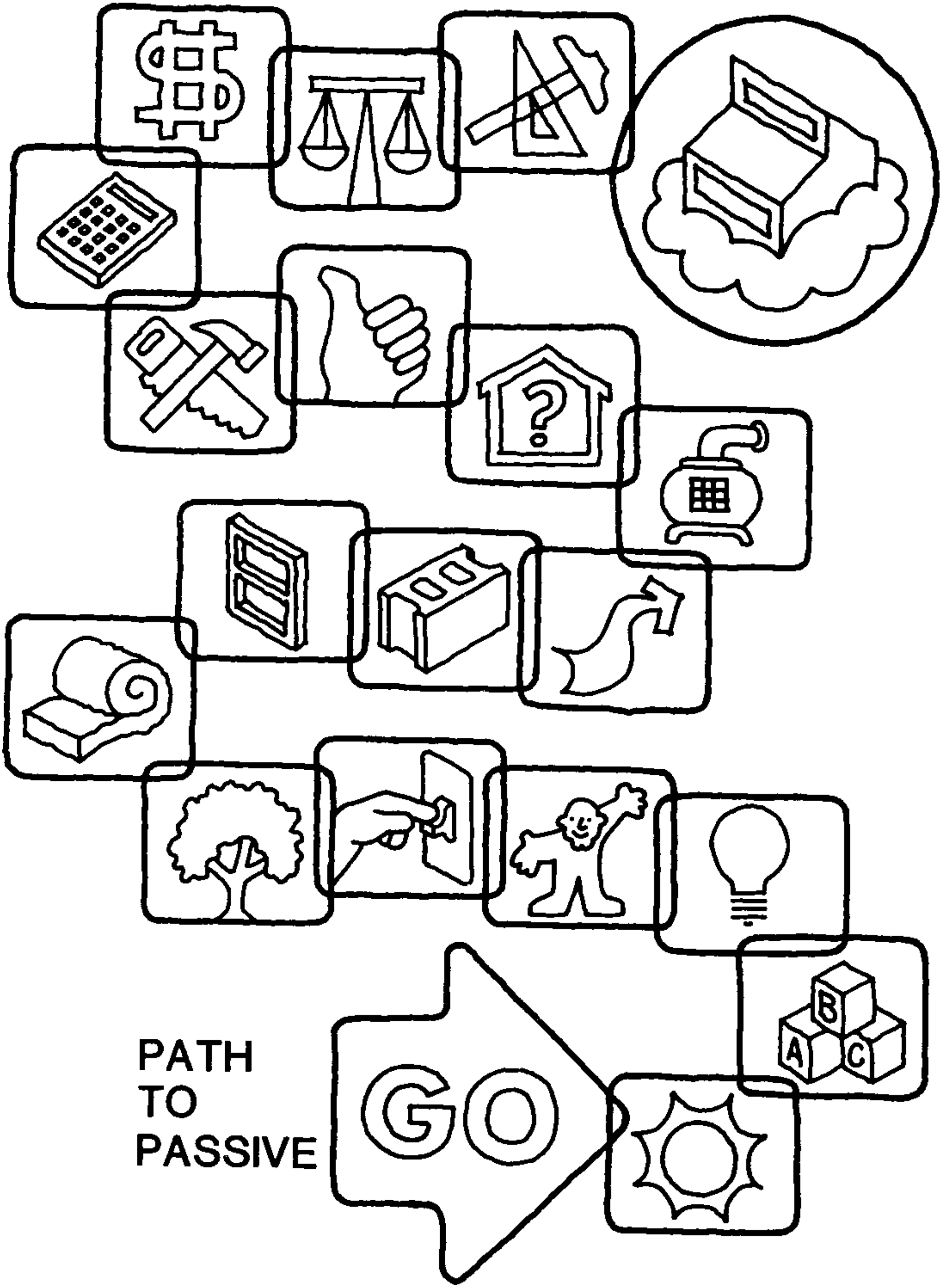
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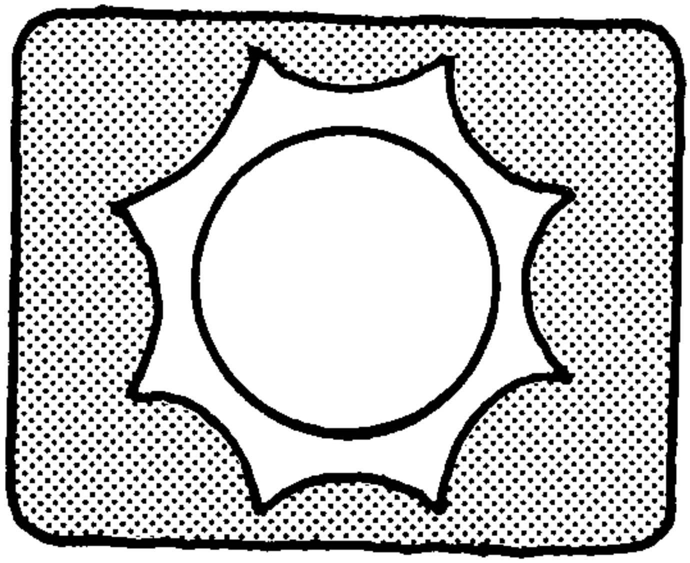
CHAPTER 0
INTRODUCTION

This chapter is a brief philosophical and historical perspective of passive solar energy.

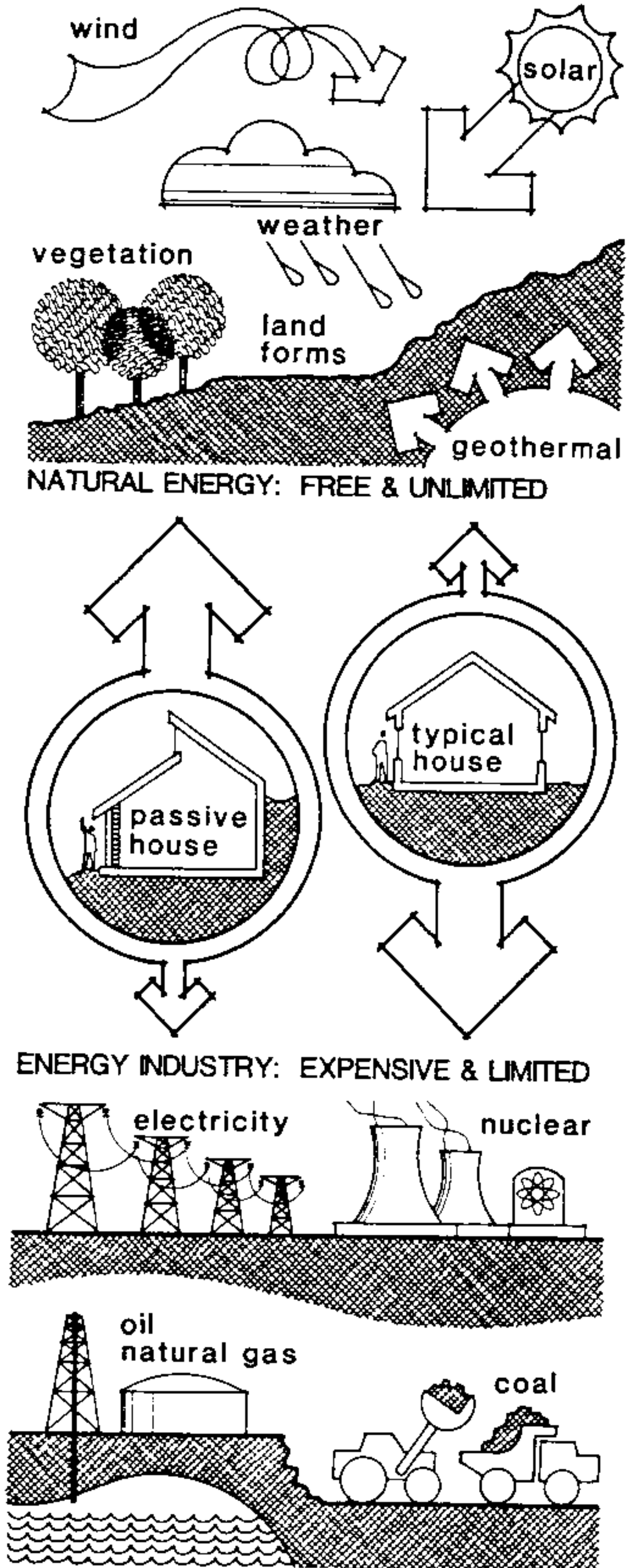


INTRODUCTION

The sun is the principal source of energy for all life on this planet: the complex interwoven web of life on this planet is dependent upon the sun for its survival. For example, the sun drives the weather patterns; it controls the various oxygen, nitrogen and carbon dioxide cycles. Man is the only species which has been able to substantially alter the environment, although only in the recent past have such actions been questioned. Our long term survival may very well rest upon our ability to temper this Promethean power endowed to us. We have yet to fully understand the lack of wisdom inherent in brokering our future with short-sighted, short-term economic gain at the expense of our environment. The "balance due in full" account with nature may be more than our heirs can pay.

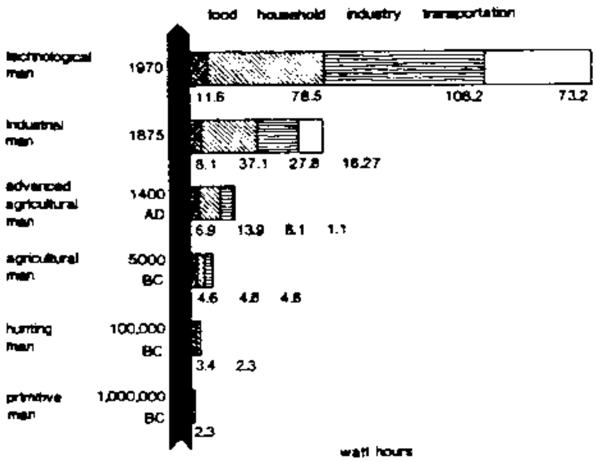
In the decades ahead, a number of fundamental decisions will have to be made with respect to our lifestyles and our responsibilities as the pre-eminent life form on Earth (FIG 0-1). The passive solar heated home is indicative of a choice made in favor of utilizing a plentiful and renewable energy source -- the sun. No other source of energy can make the claim of being unending or of being in harmony with nature.

At the beginning of this century, coal was the principal source of heat for most homes . Coal was to be supplanted by the newer and, at the time, seemingly inexhaustible reserves of oil and, later, natural gas. Generous government subsidies allowed the gas and oil industries to grow and proliferate; America grew and prospered. Our homes grew larger and their energy appetites for fossil fuels kept pace. An entire generation was nurtured on "cheap" fossil and nuclear fuels. The first storm clouds warning of energy problems gathering on the horizon were ignored in the "happy days" of the 50's. Economics has not tallied the true cost exacted

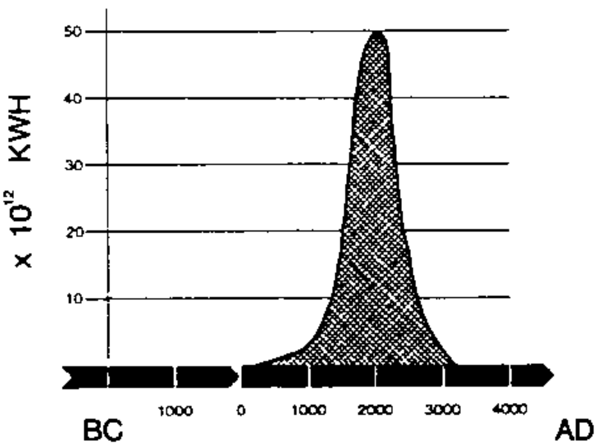


0-1 A TIME FOR CHOICES

INTRODUCTION



0–2 ENERGY CONSUMPTION HISTORY



0–3 FOSSIL FUELS: A LIMITED FUTURE

0–4 THE TAMING OF ENERGY

upon our environment. As a result, we are faced with the following questions: Can future generations pay the balance due? Has the environment's maximum stress point been exceeded?

Per capita energy consumption of primitive man, whose energy needs were principally concerned with food, was modest (FIG 0-2). Energy consumption did not increase significantly until the Agricultural Revolution. The Industrial Revolution, about 1875, brought about a quantum leap in consumption and the inclusion of a new sector -- transportation.

Each fossil energy resource is finite. At the initial stages of exploitation, supplies appear to be inexhaustible. Successful marketing increases the rate at which the fuel is consumed, and this process continues until the ease of discovery and extraction diminishes. Prices of the fuel then escalate as the resource base is depleted (FIG 0-3). At this point, threat of depletion may lead planners to consider substitution strategies such as coal gassification or shale oil for petroleum. The problem with this approach is that one is led to believe that a permanent solution has been found. However, if the substitution is another fossil fuel, the problem is only delayed, not solved. At best the substitution can only buy time until a permanent solution is developed.

Each stage in the ascent of man has involved fundamental changes in how the world is perceived and what role man plays in the scheme of life. Among our early ancestors, Peking Man had learned to use fire for cooking food and keeping warm during inclement weather (FIG 0-4). Wood was the chief source of fuel. In many parts of the world today, wood is still the principal source of energy.

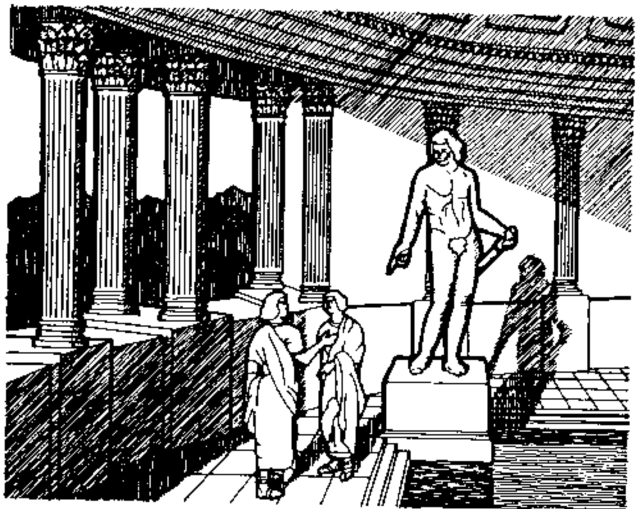
SOLAR ENERGY: A HISTORICAL OVERVIEW

Energy crises are not unique to our times. Rather, throughout history man has repeatedly been faced with the problem of finding sufficient energy supplies for warmth, to cook food, to power machines, etc. The first recorded energy crisis occurred in Greece about 500 B.C. (FIG 0-5). Wood was the principal energy source for heating, cooking, shipbuilding, and smelting. The competition for wood led to the denuding of many forests, resulting in higher prices as well as regulations to control consumption of wood. Olynthus, the first solar community using passive solar heating techniques, was built. Homes were built to capture the sun's heat through south-facing courtyards. Windowless north walls and common east-west walls completed the energy conservation package.

The scene for the next energy crisis shifts to ancient Rome (FIG 0-6). Demand for wood came from industry, shipping, and residential heating -- central heating systems in some homes consumed up to 280 pounds of wood per day. Heavily forested areas near Rome disappeared and wood was imported from as far as 1000 miles away. To extend wood resources, passive solar heating techniques were refined to include south-facing glass and the use of water as thermal mass to store the solar energy. As passive solar heating became commonplace in public baths, residences, and greenhouses, the first solar access, or "right to light", laws were enacted.

During the eleventh and twelfth centuries A.D., the Pueblo Indian culture developed the first American solar communities (FIG 0-7). Every residence had a south-facing exposure to permit sunlight to enter through doors and windows, and entire communities were planned to provide maximum solar access. Adobe construction assured sufficient thermal mass to store the heat during winter and to moderate temperatures

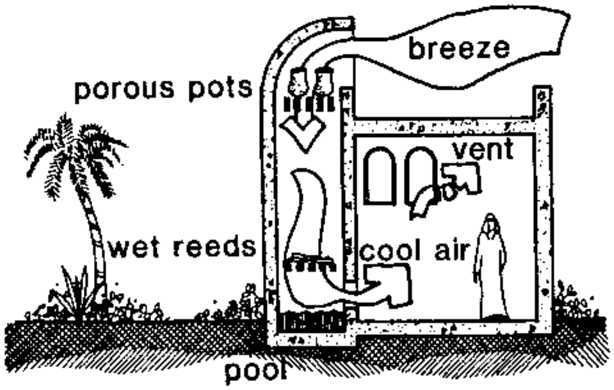
0-5 OLYNTHUS, GREECE: 500 BC
FIRST SOLAR COMMUNITY



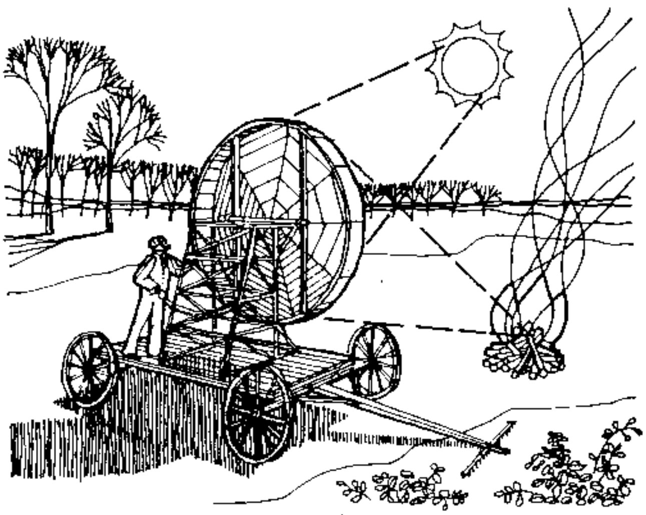
0-6 ROMAN BATH: ca. 100 AD
FIRST SOLAR ACCESS RIGHTS

0-7 MESA VERDE: 1000-1200 AD
NATIVE AMERICAN SOLAR DWELLINGS

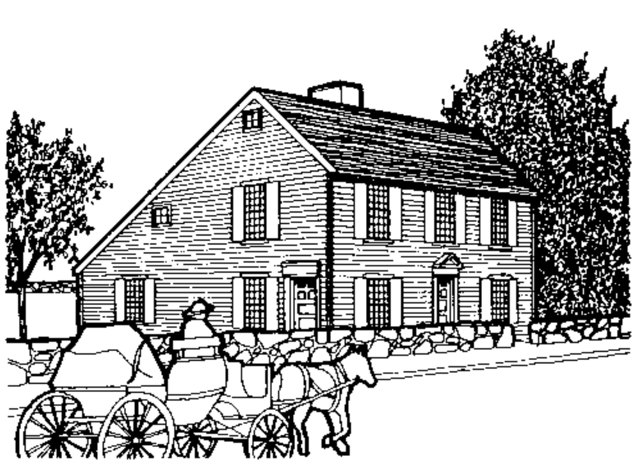
INTRODUCTION



0-8 PERSIA: 900 AD TO PRESENT
COOLING TOWER



0-9 GERMANY: 1700'S
EARLY CONCENTRATING COLLECTORS



0-10 NEW ENGLAND: 1700'S
EARLY AMERICAN SALTBOX

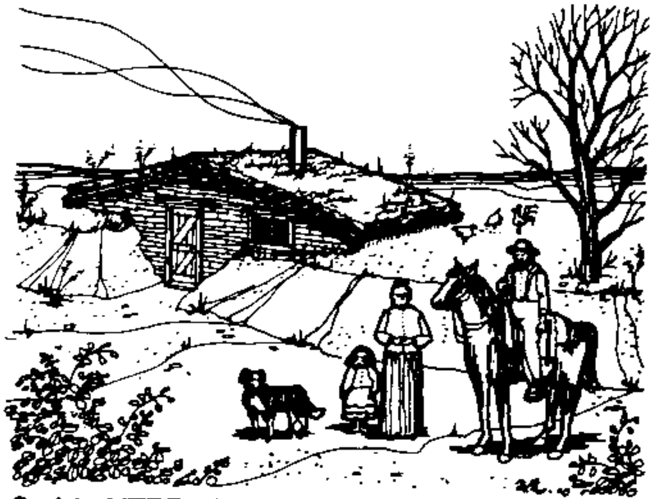
during the hot summer months. Shutters and roof insulation helped retain heat in the winter, and eaves were used to shade the sun in the summer.

The sun's energy can be used to cool as well as to heat. All wind currents are sun driven, and the Persians took advantage of this fact to keep their interior spaces cool during summer months (FIG 0-8). Breezes are ducted from roof openings down through porous pots and wet reeds and over a pool at the bottom of the chimney. In picking up moisture, the air current is cooled so air entering the living space is cooler than indoor air temperatures.

The use of the sun's energy is not limited to heating and cooling applications alone. Ancient Chinese, Greek, and Roman civilizations developed curved mirrors to concentrate the sun's rays onto a single point. Archimedes is said to have used mirrors in 221 B.C. to destroy an enemy fleet attacking Syracuse. Da Vinci conceptualized the idea of using mirrors to supply industrial hot water. In place of single piece mirror fabrication, Peter Hoesen fabricated his mirrors with brass-covered wood sections that were fitted together (FIG 0-9). The power of the mirrors was such that copper metal would melt in one second.

Early American settlers built the New England "saltbox" (FIG 0-10). The buildings were two-story with most of the rooms facing south. Only one floor faced north. Sloping roofs carried cold northern winds up and over the building. Vines above the doors and windows kept summer sun out of the home, but would permit sunlight to pass through the windows when the leaves fell in autumn.

Each environment has unique characteristics. The prairie pioneers of a century ago faced cold winters with fierce north winds (FIG 0-11) and hot, unpleasant summers. Wood was not in abundance to serve as a primary fuel. The solution was the sod house. Earth berms on the north kept out winter winds. South-facing doors and windows permitted solar gain. Dirt and sod provided roof insulation year round. The thick walls moderated temperatures, and the earth floor contact provided the additional bonus of summer cooling.



0-11 NEBRASKA: 1800'S
EARTH SHELTERED SODDY

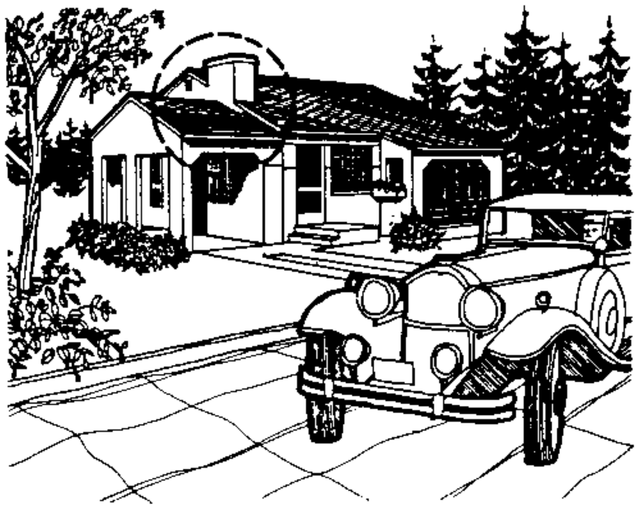
In 16th century Holland, greenhouses were utilized for horticultural purposes, which resulted in the perfection of window angles and thermal storage techniques. It was not until Victorian England, however, that the idea of the glassed-in garden, or conservatory, gained popularity . Sun-warmed and plant-moistened air could be drawn into homes which otherwise were usually cold and gloomy (FIG 0-12).

0-12 LONDON: 1890'S
VICTORIAN GREENHOUSE

Although personal bathing was popular in Rome, the practice was discontinued in Europe , primarily because heating water was a laborious and tedious process. However, in 1891, Clarence Kemp marketed the "Climax", the first commercial solar hot water heater unit. It consisted of a hot box with exposed bare metal tanks operating under city water pressure. Bathing became practical again. In 1911, the "Day and Night" solar hot water heater by William Bailey revolutionized the industry (FIG 0-13). Its insulated storage tank was separated from the collector, and the collector included a metal absorber plate operating on thermosiphon principles.

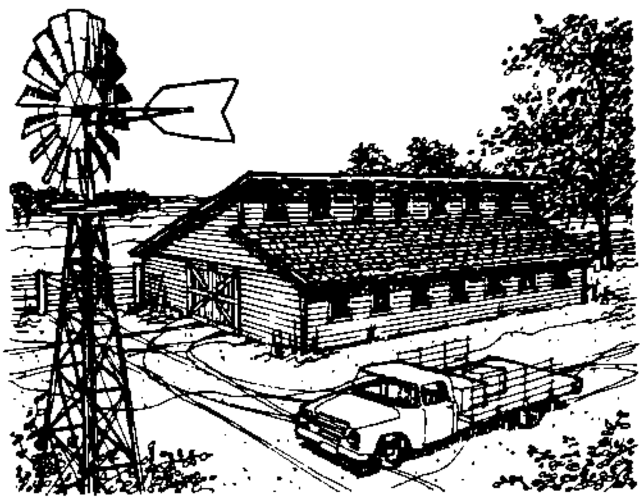
0-13 SOUTHERN CALIFORNIA: 1911
SOLAR WATER HEATER

INTRODUCTION



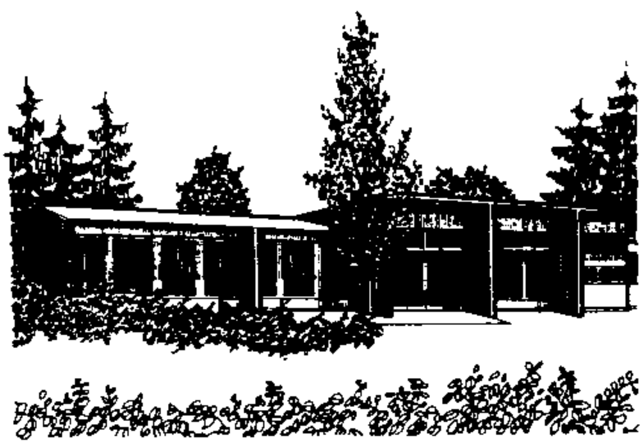
0-14 FLORIDA: 1930'S
IMPROVED SOLAR WATER HEATER

Florida's population grew rapidly during the Roaring 20's and by 1941 more than half of Miami's population was using solar heated hot water (FIG 0-14). A popular model of solar hot water heater was the "Duplex", an improved version of the "Day and Night". Soft copper replaced steel tubing, the spacing between tubing was reduced, and the collector box was insulated and further improved by switching to steel construction.



0-15 NEBRASKA: 1940'S
LIVESTOCK SHELTER

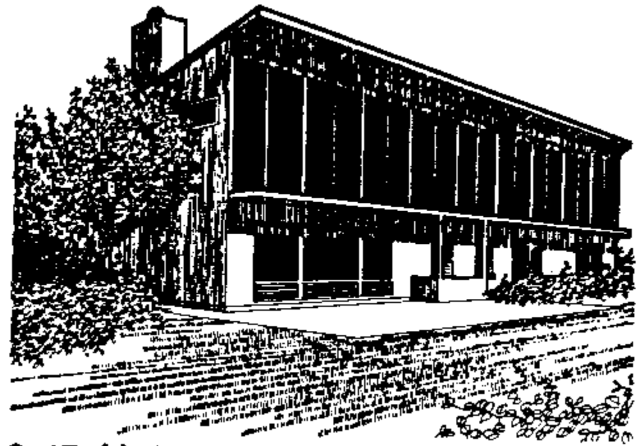
In the midst of the great Depression, a number of programs were instituted to benefit farmers, including one by the Farm Security Administration, in which an existing design of an animal facility was altered to reduce energy consumption (FIG 0-15). These alterations included windows and clerestories facing south to maximize solar gain and a long roof line pitched to deflect the cold winter winds up and over the building. Many of these animal barns dotted the prairie landscape of the 30's and 40's. The famous architect Saarinen is said to have commented: "Kids should be able to live as well as these chickens".



0-16 ILLINOIS: 1941
PASSIVE DESIGN BY KECK

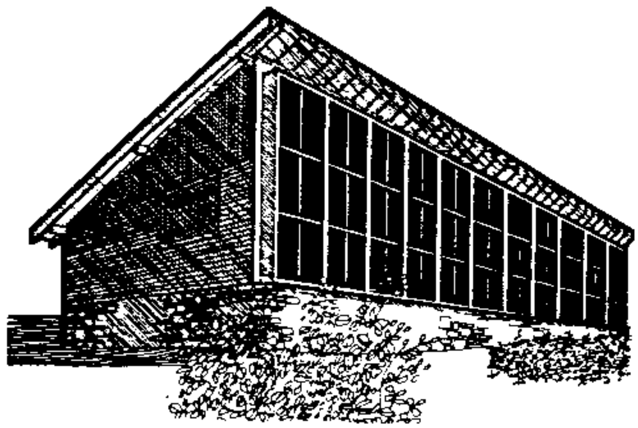
The modern passive solar era began in the 1930's and 1940's with George Fred Keck, who designed homes with a southern orientation. Keck used double paned glass which allowed the home to retain more heat in winter and overhangs to prevent overheating in summer (FIG 0-16). In 1940 the first modern passive solar heated home with a complete south wall of glass was built for Howard Sloan, a real estate developer in Chicago, who, in 1941, built Solar Park, the first American solar development.

In 1948, Maria Telkes, then a research associate at MIT, worked with Amelia Peabody to design a 100% solar home without backup furnace. Called the Dover House (FIG 0-17) the structure had a vertical collector with 180 square feet of south-facing glass. Hot air was ducted from the air collector to a 470 cubic foot storage unit comprised of glaubers salt in five gallon steel cans. The storage capacity was 5 million btus, enough to heat the house through a week of cloudy days. Unfortunately, the system was only successful for 2-1/2 winters, after which problems developed in the salts.



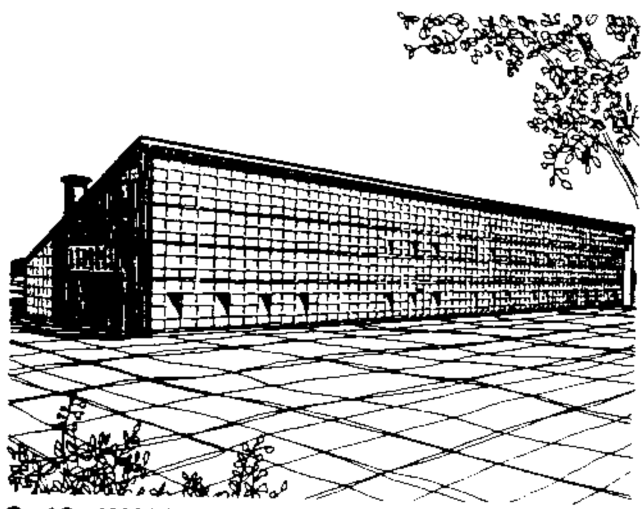
0-17 MASSACHUSETTS: 1948
DOVER HOUSE BY MARIA TELKES

In 1956 in the mountains of southern France, Felix Trombe built the first of a series of solar buildings (FIG 0-18). Today Trombe is recognized as one of the modern pioneers of passive solar energy, and the concept of placing thermal mass directly behind south-facing glass is frequently referred to as a Trombe wall. Concrete one-foot thick and painted black serves two purposes: it provides thermal storage and acts as a structural element. Heat absorbed by the concrete migrates to the inner wall and radiates into the living space during the evening.

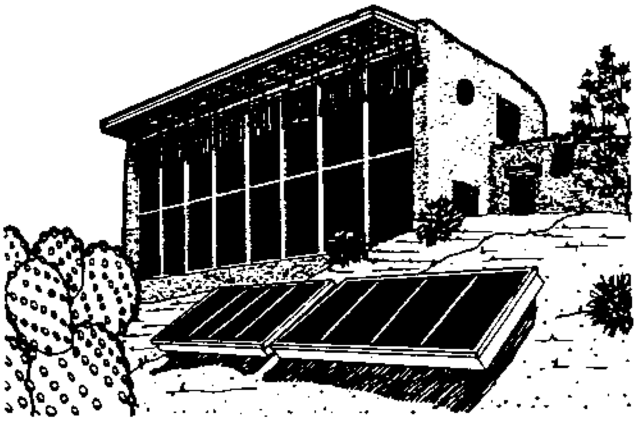


0-18 PYRENEES, FRANCE: 1956
FELIX TROMBE HOUSE

The Wallasey school in Liverpool, England is another early example of passive solar energy design (FIG 0-19). Built in 1961, the school's entire 230' by 27' south facade is in two glass layers. The inner layer diffuses the impact of direct sunlight. This diffused light strikes concrete floors, ceilings, and brick walls directly and these contain sufficient mass to limit the daily temperature swing to $6^{o}F$. The school has yet to require auxiliary heating.

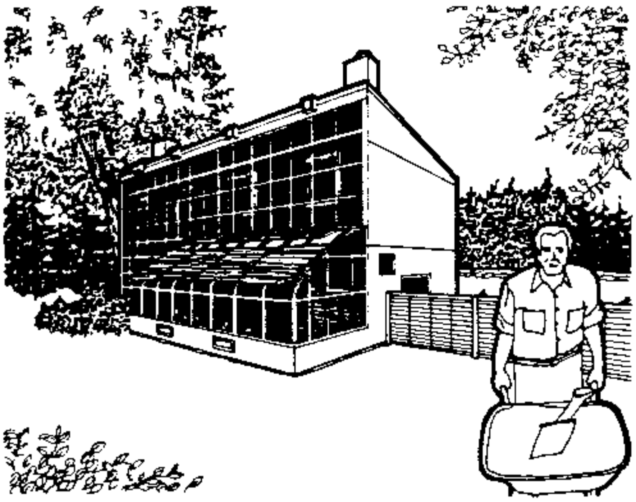


0-19 WALLASEY, ENGLAND: 1961
SOLAR HEATED SCHOOL



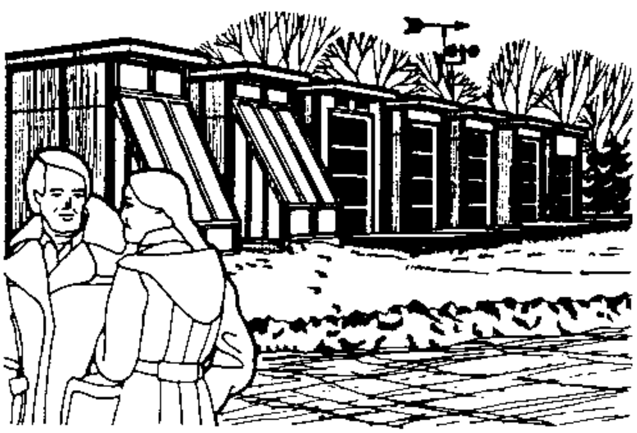
0–20 NEW MEXICO: ca. 1970'S
DAVID WRIGHT DESIGN

The sun provides 90% of the annual energy requirements of a home built in 1974 by David Wright (FIG 0-20). Most of the nearly 500,000 btus collected each day are stored in the 2' thick adobe floor and 13" to 17" thick adobe wall, insulated with 2" of polyurethane foam, and enough heat can be stored to provide heat to the house for three to four sunless days. The interior space fluctuates between 58°F and 80°F during the winter.



0–21 PRINCETON, NEW JERSEY: 1975
DOUG KELBAUGH HOUSE

The Doug Kelbaugh home, (FIG 0-21) built in 1975 in Princeton, N.J., combines a Trombe wall with greenhouse. It overcomes the chief objection to placing thermal mass between the living space and the south-facing view by providing for windows to be installed in the Trombe wall. During 1976-77, the average temperature was 63°F downstairs and 67°F upstairs.

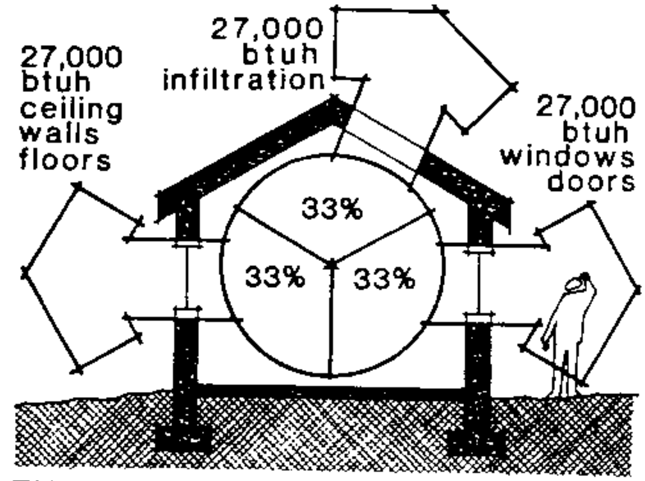


0–22 OMAHA, NEBRASKA: 1978
UNO PASSIVE SOLAR TEST PROJECT

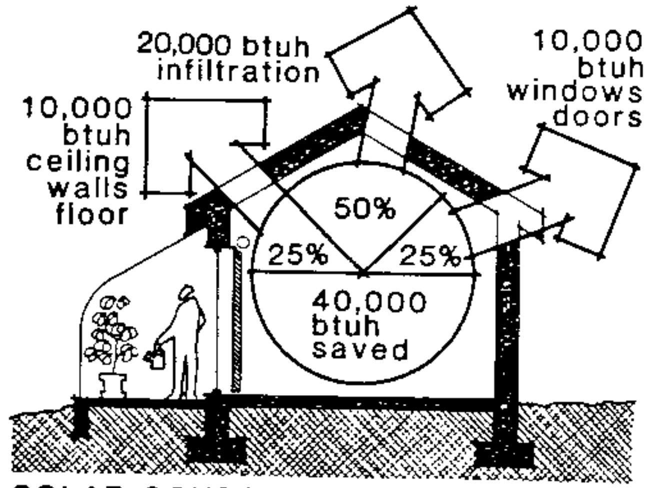
Begun in 1978, the Passive Solar Energy Test Facility, located at the University of Nebraska at Omaha, now ranks as one of the largest passive solar test facilities in the world (FIG 0-22). The study of different passive solar heating techniques has been heavily emphasized, especially those that are suited to northern climates. Greenhouse, earth sheltered, and super-insulated test rooms have been built at the test site. The only double shell or continuous thermal envelope test room known to be in existence has been undergoing monitoring since 1979. Experiments with cooling tubes and testing of commercial products are planned. The Passive Solar Research Group (PSRG), consisting of volunteer faculty and students, manages the test facility.

WHY PASSIVE SOLAR ENERGY?

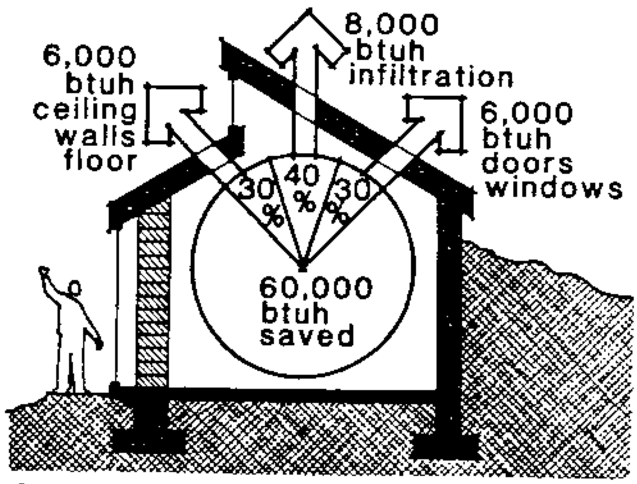
Passive solar heating technology has been proven to be a viable, cost-effective, maintenance-free, low technology, and almost universally applicable strategy in the field of energy efficient house design (FIG 0-23). Because conservation is a cornerstone of any passive solar energy strategy, a solar-conscious home will reduce energy consumption by 50% or more. For those solar structures which have been optimally designed, the savings can amount to 80% or better compared to a conventionally-designed home. It appears that passive solar energy is one of the principal strategies which will be utilized by the homeowner to combat the inevitable upward spiral of home energy costs.



TYPICAL HOUSE IN JANUARY
(80,000 btuh loss)



SOLAR CONSCIOUS HOUSE
(40,000 btuh loss)



OPTIMUM SOLAR HOUSE
(20,000 btuh loss)

0-23 WHY SOLAR?