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A REPORT ON A
SABBATICAL LEAVE
FOR
JULY AND AUGUST 1977

Presented to the
Faculty, the Administration, and the
Board of Trustees of
Mt. San Antonio College

by
Thomas W. Bull

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CHAPTER I

THE PROBLEM AND DEFINITIONS OF TERMS USED

"By 1979 the Energy Research and Development Administration plans to have solar heating, and in some cases solar cooling, systems installed in 1,300 residential and 200 non-residential buildings located in most of the nation's climatic zones."

The above statement, excerpted from a phamplet published by the Atlantic Richfield Corporation, is typical of the interest and accelerated activity taking place in the field of solar energy. For the United States to sustain reasonable economic growth, energy consumption will have to increase by nearly 50 percent between now and 1990. We currently have sufficient energy only because we are able to import approximately 40 percent of the oil we need, which is double the volume we imported six years ago. As we face the realization that increasing dependence upon foreign energy sources can lead to economic chaos, we are forced to seek alternate energy resources. Thus, the search for efficient applications of solar energy.

When one considers the enormity of available solar energy, it seems prudent and logical to pursue the search. It has been determined by experts that in the United States alone 9,000 trillion kilowatt hours of solar radiation are received each year--about 2,000 times our annual production of coal. But, the reader should be aware that applications of solar energy are not new nor unique.

Over one hundred years ago, a solar still covering 50,000 square feet was built in Chile to desalinate sea water and at the Paris Exhibition of 1878 a solar-powered steam engine ran a printing press. In

1913 a 50 horsepower solar-operated engine was used to pump irrigation water from the Nile River and in the 1920's solar collectors for home heating were introduced in Florida and in California. One should ask why solar energy applications are not more advanced if they have been in existence so long? The simple fact is that natural gas was made available to the consumer and industry at a far more reasonable cost. However, now that we must face the reality that our natural gas resource is not unlimited, we must develop additional back-up resources. Solar energy is unlimited and its use and application has a negligible effect in the disturbance of the environment.

I. THE PROBLEM

Statement of the Problem. What are the design requirements of a residence or a commercial building which utilizes the use of solar energy? What electrical or electro-mechanical equipment is needed in a solar energy system? What sources are available for the acquisition of solar energy equipment? What is the relative cost for installation of solar energy equipment and how does one evaluate efficiency? How does the consumer know that he/she is dealing with a legitimate, knowledgeable dealer? All of these and many more questions have a positive effect on the educational process if we are to train our students to effectively meet the needs of industry. We are not now answering these questions for our students, but it is our intention to do so as we conscientiously revise our curriculum to provide the knowledge necessary to work in the fields related to the application of solar energy systems.

Importance of the Study. Why should Mt. San Antonio College, an educational institution, be concerned about applications of solar energy? Solar energy is fast becoming a new industry in the United States. Its effect upon the manufacturing, construction, service, and agricultural industries is being determined in ever increasing volume. Both residential and commercial buildings are utilizing solar energy systems. This has a major effect upon design standards in the field of architecture and construction. Heating, air-conditioning, and refrigeration systems are being changed to accomodate the application of solar energy. This affects the plumbing, heating, air-conditioning, and equipment manufacturing industries as well as the service industries involved in their products. The agricultural industry is experimenting in the use of solar energy in food processing. All of these facts lead to one conclusion--tomorrow's workers must be trained in the applications of solar energy systems.

Limitation of the Report. Architects, engineers, and maintenance personnel have one very important procedure in common. They all collect and utilize technical data from manufacturers for use in their respective businesses. Without this data their respective jobs would be extremely difficult if not impossible. There is no need to redesign and manufacture existing products. Even if a design is new, it usually utilizes existing components offered by a variety of manufacturers.

There is no intent by the author to describe in technical detail all of the products or procedures used in solar energy systems. It appeared more practical to identify participants, determine the extent of participation, and compile useful information as a resource for both students and faculty.

II. DEFINITIONS OF TERMS USED

Active Residential Solar Heating System. A solar heating system that utilizes forced circulation of the collection and distribution transfer media. It is a system that combines the means for collecting, controlling, transporting, and storing solar energy with the primary heating system in a building.

Collection Circuit. The path followed by the collection transfer medium as it removes heat from the collector and transfers it to storage.

Collector Efficiency. Ratio of the amount of heat usefully transferred from the collector into storage to the total solar irradiation transmitted through the collector covers.

Distribution Circuit. The path followed by the distribution transfer medium as it removes heat from storage and transfers it to a building.

Downpoint Temperature. Temperature of the distribution transfer medium as it leaves storage below which useful heat cannot be delivered.

Drawdown. The removal of all useful heat from storage.

Fixed Plate Collector. A device for collecting solar radiation and converting it to heat. It is usually stationary and does not concentrate the incoming radiation. An average size collector might be two feet wide by eight feet long by four inches thick and consists generally of the following parts:

1. A cover which admits solar radiation and insulates against heat loss.

2. A plate which absorbs solar radiation and converts it to heat.
3. A transfer medium which carries heat away from the collector for storage or use.
4. A frame which supports all collector components.
5. Insulation which reduces the heat loss from the back side of the collector.

Heat Exchange Flow Pattern. The relative flow arrangement of the collection and distribution circuits in storage. Typically, they are:

1. Counterflow, which is the collection and distribution transfer media flow in opposite directions through storage.
2. Parallel, which is the collection and distribution transfer media flow in the same direction through storage.

Passive Residential Solar Heating System. A solar heating system that utilizes natural circulation of the collection and distribution transfer media.

Primary Heating System. A system used to heat a building when the solar heating system cannot provide the required useful heat. This system may be a conventional electric, gas, or oil furnace or heat pump.

Reflector. A mirror or other material which contains a bright (light) surface used to increase and direct shortwave radiation input into a collector.

Sensible Heat Storage. A heat storage medium in which the addition or removal of heat results in temperature change. Typical mediums are water and ordinary gravel.

Solar Furnace. A totally self-contained solar heating system.

Stagnation. A condition in which heat is not added to or removed from storage mechanically but only as a result of natural heat transfer from the storage container.

Stratification. The existance of persistent temperature gradients in storage mediums.

Thermal Lag. The amount of heat necessary to reachieve downpoint temperature after collection is resumed following a period of stagnation.

Transfer Medium. The substance that carries the heat from the collector to the storage medium and from the storage medium to the building. Typical transfer mediums are water, air, or a water-ethylene-glycol solution.

Useful Heat. Heat delivered by the solar system on demand by the thermostat that contributes to a reduction in the conventional fuel heating cost. Useful solar heat replaces an equivalent amount of heat that otherwise would have to be provided by the primary heating system.

CHAPTER II

RESEARCH PROCEDURES

The author corresponded with forty known businesses and educational institutions to predetermine the value of potential information relative to solar energy applications. Several letters were returned unopened, and a few were answered. However, after screening all available information, the author embarked on a 6,000 mile tour of seven Western states to compile information on solar energy systems. Between the time of correspondance and the time of visitation, some of the businesses had either moved or gone out of business. Due to a lack of sufficient time, no follow-up procedures were initiated in cases such as these. This report will include only those organizations having some information to contribute to the field of solar energy.

I. THE SAMPLE

Population Sampled. The "population" sampled was composed primarily of service and sales organizations and educational institutions known to be involved in some aspect of solar energy research or activity. In some cases, an individual who was engaged in research or manufacturing was the source of information. In other cases, some institutions had initiated projects utilizing solar energy which involved many people who demonstrated diverse educational, service, or manufacturing expertise.

In still other instances, information was gathered from receptionists, clerks, sales personnel, educators, and educational classified personnel.

II. MEASURES AND METHODS USED

During the preliminary research into the subject of solar energy applications, the writer found numerous phamplets published by the Environmental Research and Development Administration (ERDA) relating to solar energy. However, except for a few "do it-yourself" type publications, it was determined that there are a limited number of formal publications dealing specifically with solar energy.

Newspaper articles are numerous and becoming more plentiful. Additionally, there is a noted increase in the publication of "papers" by individuals through committees in a variety of technical societies and professional organizations. All of these sources will be made available to persons interested in the field of solar energy through this report.

There was no questionnaire provided prior to visitations with institutions. The reasons were obvious. Having no advanced information from institutions on products or research limitations prohibited the construction of an intelligent and applicable questionnaire. In some instances, it was impossible to determine if a company furnished services or products after corresponding with them.

Personal Interviews. At the beginning of this sabbatical research project, the author was a layman seeking information relative to a new field of knowledge. If one lacks knowledge of a subject, even basic intelligent questions arise with some difficulty. Therefore, it appeared advisable to read as much printed material on the field of solar energy as I could find in order to familiarize myself with basic concepts as well as "trade terminology."

All interviews were unstructured and spontaneous. They had to be of necessity, for I found myself interviewing a technician at one moment and a doctor the next. It was impossible to schedule interviews in a majority of circumstances because I had no advanced information on who was available or who was knowledgeable. However, I was well received in all visits, and I found most people to be very receptive and eager to give information about their respective activities relative to solar energy. Some interviews were of short duration and confined to a single location while others were extensive, involving several people and a variety of locations in one facility. Most interviews were completed in one visit and, in a few cases, I had to return at a scheduled time to achieve my objectives. Unsuccessful contacts were due to a variety of causes. Four or five companies had moved, two or three had gone out of business, two were closed and on vacation, and two or three were closed for no apparent reason.

III. THE RESEARCH PLAN

This investigation utilized practical techniques rather than theoretical. The intent was to 1) find out who was actively engaged in an activity related to solar energy, 2) compile information on their product, research project, or service, and 3) make the information available to teachers, students, and others interested in energy conservation.

With much difficulty, the author compiled a tentative list of potential contacts prior to the sabbatical period. Correspondance was initiated to determine the feasibility of either a visit or simply additional corresponance. It was mentioned previously that several of the letters were returned unopened due a lack of a forwarding address or other circumstances. Most correspondants were pleased to know of my interest and encouraged further contact. Several firms enclosed preliminary information regarding their products or service and extended an open invitation to visit their facility. Those who answered my correspondance expressed a desire to cooperate fully in supplying information which might be helpful in training future technicians for the field of solar energy.

CHAPTER III

REPORTS ON VISITATIONS

Fafco, Inc., Sunnyvale, California

Since it was founded in 1970, Fafco has manufactured and installed over 8,000 swimming pool heating systems throughout the world. The Fafco solar collector, it is claimed, makes solar heating practical for nearly everyone because it uses the sun's energy to heat water very efficiently. Hundreds of small hollow channels in the plastic collector provide the greatest possible contact surface area between the water and the heated surface of the panel. The plastic material has been tested specifically for efficiency in the transfer of heat to water.

Fafco manufactures two basic panel collector sizes. One is four feet by eight feet, and the second is four feet by ten feet. The thin, black plastic panel is not enclosed (boxed in) and has no glass or heat trap area except within the parent material.

At each end of the solar panel is a header manifold which distributes water uniformly throughout the panel or to the pool. The even distribution of water to each panel is essential in that it eliminates "hot spots" and insures that no matter how many panels are used, each will receive an equal flow of water for uniform heating.

Today is a time of emphasis on energy conservation, particularly energy which is consumed for pleasure activities rather than for the necessities of life. To this end, Fafco is dedicated to furnish an economical means to heat swimming pool water. Their products are significantly applicable to heating swimming pool water because most pools already contain essential equipment necessary to the system. The pool is the heat storage medium and pumps and controls are normally required for a filter system. These facts tend to reduce the cost of the addition of solar collectors for heating purposes.

The Fafco Solar Collector has been extensively tested for product reliability, and the company has documented the results of all tests.

Arizona State University, Tempe, Arizona

Arizona State University, in cooperation with the Arizona Solar Energy Research Commission and the Arizona Public Service Company has been increasingly involved in research on solar energy systems. This institution has continued to demonstrate leadership by sponsoring conventions, seminars, and conferences on solar energy application and has initiated optional course selections in the Architectural major for students interested in this area of study. Mr. Jeffery Cook, A.I.A., and Mr. John Yellott, author and researcher, lead the College of Architecture in the pursuit of knowledge in the study of applications of solar energy.

The University maintains a small, but complex, research station across the street from the Architectural Center. Experiments are being conducted on a variety of solar collectors. Each collector is monitored daily by special instruments to record heat intake, heat trap, and general efficiency.

An additional unique experiment is being conducted on a small house. It is called a "wet house" due to the existence of a layer of water on the roof. The water may be used to either heat or cool the house, depending upon the setting of controls which monitor inside temperatures and activates pumps which cause the circulation of the water pool.

At the time of my visit, none of the faculty were available. However, Mr. Cook came in to pick up some papers for an off-campus meeting, and I had an opportunity to talk with him for a few moments. He agreed to send me detailed information on their solar energy experiments, but none has yet been received. Had the timing of my visit been more appropriate, I would have collected valuable information about solar energy application.

The Sundu Company, Anaheim, California

Mr. A. J. (Tony) Meagher has been actively experimenting in the field of applications of solar energy for over eighteen years. During this period, he has developed a variety of solar collectors while improving on the design and concentrating on cost-effectiveness for implementation.

Mr. Meagher's collector is very unique when viewed in comparison to most collectors. The average collector, as described in this report, is basically a "box" consisting of a frame, insulation, heat absorption material which also provides circulation space for water, a heat trap space, and a glass or transparent plastic cover. The Sundu Collector is one self-contained black plastic unit, having no frame and requiring no enclosure of any kind. The basic unit of the collector is 5/16 of an inch thick by 6 inches wide. It is a hollow plastic extrusion with space inside of the extrusion for the circulation of water. The extrusions may be of any practical length and are placed side-by-side to form any width required. A panel is formed when several extrusions are attached to a plastic pipe header at each end of the extrusions. The extrusions are, basically, flat plastic pipes which receive circulating water from pipe headers at the bottom end and discharge water to a similar pipe header at the top end. The greater the area of the solar collector that is employed, the greater the heat gain. The Sundu solar heater, although primarily designed for heating swimming pool water, can be adapted to many domestic, farm, commercial, and industrial uses. The amount of area of the collector required to effectively provide heat for swimming pool varies between 50% and

75% of the surface area of the pool.

The advantages of the Sundu Collector are numerous. It is one self-contained unit, it is relatively light in weight, and perhaps the most significant advantage is that it is far less expensive and easier to install than most, if not all, other collectors.

Mr. Meagher posesses a wealth of information concerning the study of the field of solar energy and he is extremely receptive to inquires regarding its application and use.

The University of Arizona, Tuscon, Arizona

Due to an exceptional amount of money grants from a variety of sources, the University of Arizona has been and continues to carry on extensive research at their Environmental Research Laboratory at the Tuscon International Airport.

In addition to extensive solar energy research, the lab, which covers a large area and contains several unique buildings, is devoted to the development of advanced technology systems of food, water, and energy production, and the evaluation of social, environmental and commercial impacts of such systems. The entire complex is referred to as the "Greenhouse."

The Greenhouse is best known (internationally) for the design and horticulatural development of controlled-environment systems for high-volume vegetable production in coastal and inland deserts.

Although not a part of Tucson installation, the University operates one of the leading intensive-culture shrimp research projects in the world at the Mexican coastal field station it shares with the University of Senora. This hatchery produces all three species of Gulf of California marine shrimp. Initial program objectives are the development of artificial feeds, systems of water quality and animal health management, and genetic selectivity. The basic goal is the development of commercially controlled environment systems for the production of animal protein.

Since 1950 the University has been engaged in solar energy research and applications and has developed innovative techniques for the solar distillation of sea water. Continued research in solar thermal energy collection and storage is now directed toward space heating, the capture and use of rejected heat from industrial processes, improved operations of mechanical refrigeration systems, multiple-stage and indirect evaporative cooling, and the design and operation of on-site total energy plants.

In short, the University of Arizona appears to be carrying on an in-depth research in a variety of directions on systems of tremendous significance to man and his natural environment.

Solaron Corporation, Denver, Colorado

In 1943 Dr. G. O. G. Lof built and installed in his home in Boulder, Colorado, a successful experimental solar heating system, and in 1957 Dr. Lof installed a prototype circulating air system in his Denver home. This system has functioned with no major problems and with virtually no maintenance cost.

In early 1974, Dr. Lof and several associates organized Solaron Corporation to design, manufacture and market solar energy heating systems for residential, commercial, and industrial buildings. The company's technical staff designed a solar air heating production model, based on Dr. Lof's knowledge and accumulated years of practical experience with the 1957 prototype system in the Lof residence. Since 1974 Solaron has furnished solar heating systems for a large number of residences and other buildings in the Rocky Mountain region, and several Solaron equippped buildings are in operation and under construction in other parts of the country.

Through years of research, Solaron has concluded that when a solar heating system is designed for a building its cost is minimized by first reducing the heating load of the building to a practical minimum. Optimal use of insulation and double glazing and air infiltration control substantially contribute to a lower capital investment in solar equipment. For the greatest economy, the solar heating system is sized to give the maximum energy cost savings per unit of initial investment. The savings are in turn dependent on the price of conventional energy and the solar radiation available. These factors vary widely over the country but, in general, the higher both of them are, the greater the savings and the larger is the fraction of the total heating load that should be carried by solar energy. Unless dictated by unusual factors, 50 to 80 percent of the annual heating requirement is a practical and economical range for the solar portion. Studies have shown that a Solaron heating system usually can provide space hating at costs lower than those of electricity and, in the near future, at costs competitive with those of fuel oil. The energy cost savings pay for the initial investment in 8 to 16 years, depending upon energy costs. The annual energy and tax savings normally exceed the annual mortgage payments on a Solaron system.

The Solaron Corporation solar heating system is effective in residential, commercial, and industrial buildings. Unlike other systems where water is the heat transfer medium, Solaron utilizes air as the heat transfer medium. The heat storage unit is a pebble bed. The flat plate collector is fabricated from steel sheet metal and contains two sealed glass covers. It consists of a combination of factory preassembled panels 3 feet by 6½ feet in size. The collectors can be mounted directly on the south facing roof of a proper tilt or, with proper supports, on a flat roof or in another suitable location near the space to be heated. A factory preassembled air handling unit containing automatically actuated dampers, an optional domestic water preheater, and a temperature control panel completes the Solaron package. Conventional auxiliary heating systems are provided and installed by others.

Solaron has an impressive list of solar installations throughout the United States. Most are privately funded, some are funded by grants from H.U.D., and others were funded partially by E.R.D.A. grants. Solaron also makes available to educational institutions, at a reduced price, the Solaron Application Engineering Manual for use in designing systems for homes, commercial, and industrial structures.

Twin City Builders, Inc., North Bend, Oregon

Mr. Steve Graves, Builder, and Mr. Ronald Stromme, Realtor, combined their efforts to construct a split-level, modern home utilizing the latest known methods for heating and airconditioning by solar energy. The solar energy system is backed up by an electric furnace and an electric hot water heater. The entire system, with the exception of the solar panels, is located in the basement of the house adjacent to a two-car garage. The system is extremely compact and highly sophisticated, having been engineered with care and precision. Each pipeline contains one or more special valves to control the system in addition to a series of monitoring devices. The system contains such devices as a non-toxic anti-freeze tank, air separator, 15-gallon expansion tank, preheater, heat exchanger, and special by-pass valves which are automatically controlled throughout the system. An anti-freeze liquid is pumped through the solar collectors which is heated by the sun's rays. The heated anti-freeze is them pumped into the heat exchanger, which heats water also being pumped through the heat exchanger. From there the heated water goes to a coil system inside the forced-air system and the air is heated as it is forced over the coils. The hot water from the coil system is then pumped into a preheater which in affect will take the chill out of the water going to the hot water heater. From there the hot water is then pumped into the main storage tank. The system is completely automatic and only requires the attention of an individual to set the main thermostat. The system will draw from the sun during the days and from the storage tank during the non-sunny days and during the night. If there is not sufficient heat from the solar system, the electric furnace will automatically activate to supply the necessary heat for the building.

There were no details provided relative to the construction of the solar energy panels except that they were purchased from a reliable firm specializing in this type of research.

Mr. Henry Mathew, Builder, Coos Bay, Oregon

For approximately sixteen years, Henry Mathew has been constructing experimental solar energy systems and components. During this same period, he has been carrying out a variety of tests and recording all information relative to the tests.

After five years of research, he decided to build a home utilizing a solar energy heating system which he had developed. A three-bedroom home was constructed with the specific purpose of heating by solar energy. The materials and equipment used in construction were of simple, basic form obtainable in any medium-sized community. Although the materials and equipment are simple, the total system is extremely large and complex.

Two separate solar energy panel systems were constructed to provide energy for heat. The main system, which is constructed on the roof of the house, is five feet high by sixty feet long. It extends the full length of the house roof. An auxiliary supplementary system was added to the original system in 1974. This addition was constructed in the form of an "A" frame behind the house and at least one hundred feet away from the house. The solar panel is five feet high by forty feet long and is positioned on the supporting "A" frame approximately eight feet above the ground. A unique feature of this particular system is the addition of a horizontal reflective surface constructed along the length of the panel and at the bottom edge of the panel. The reflective surface is covered with ordinary household aluminum foil. The purpose of this surface is to catch additional solar rays and reflect them up into the solar panels in a more concentrated form, thus increasing the heat trapped in the system. The front slope of the roof of the house is also covered with aluminum foil for the purpose of reflecting additional solar rays up into the solar panels located at the apex of the slope.

The solar collector panels are all "homemade." They are of simple construction consisting primarily of one-inch angle iron frames, one-quarter inch plywood backing, two-inch fiberglass insulation, corrugated aluminum (heat absorption surface) painted black, one-half inch galvanized iron pipe painted black, and single strength window glass panels to allow the sun's rays to enter and to trap the heat. The pipe (which conveys the water through the system) is fastened by wire into every third corrugation of each panel.

The main source of heat storage is an 8,000 gallon "homemade" steel water storage tank which was constructed below the floor of the house. Adjacent to the tank, and also under the house, is a specially constructed air circulation system. Thermostats on the roof control water circulation through the system and into the tank. A thermostat in the living room controls a series of dampers which in turn allows warm air to circulate throughout the air circulation system and into the house. The total heating system is far more massive than anything that I have observed during my investigation. The Coos Bay area is noted for excessive moisture and cloudy conditions, but Mr. Mathew declares that his system maintains comfortable heating conditions throughout the year. He has a fireplace in the living room for an auxiliary heating system, but utilizes it no more than four or five times a year. A person interested in solar energy heating systems could learn much from this system, but they could also learn what not to do when constructing a home heating system.

California Polytechnic State University, San Luis Obispo, California

Dr. Jens Pohl, a member of the staff of the School of Architecture, is an internationally known and respected leader in the field of solar energy research and design. I interviewed Dr. Pohl on Wednesday, August 3, 1977, during summer session classes at Cal Poly, S.L.O. Although Dr. Pohl mentioned several areas of research in the field of solar energy, he emphasized two extensive projects currently being monitored by students and staff.

The first project is referred to as the San-Supported Solar House. Under Dr. Pohl's direction and aided by a National Science Foundation Grant, construction commenced in March 1974. With typical ingenuity, Dr. Pohl selected students from a variety of disciplines to assist in the research and construction of this unique structure. Involved in the project were students majoring in Construction Engineering, Architecture, Landscape Architecture, Business Administration, Agriculture, Environmental Engineering, and Home Economics. The design of this structure is based on the concept of fluid-supported construction developed by Dr. Pohl in Australia and is the third structure in a series of prototype multistory buildings that have been constructed in Australia and the United States since 1972. The basic concept of a fluid-supported structure is revealed as an over-sized column (or columns) of relatively thin steel sheet wall filled with a liquid. The purpose of the liquid is to pressurize the interior of the column to prevent buckling or crinkling. However, the use of a liquid proved impractical due to leakage and, eventually, sand was substituted as the means of pressurizing the column. In addition to providing structural support for roof trusses, the sand is heated by use of solar energy and provides dwelling heat for up to five days.

The solar collector consists of a 1,300 foot long, 3/4 inch diameter, black polyethylene hose laid on to the roof surface of the dwelling in the form of a spiral. The hose is glazed over with a single layer of Filon Tedlar coated panels which serve as a retainer and heat trap in addition to being weather resistant. It has been determined that the 330 square foot solar collector operates at an estimated 35 percent efficiency while providing 100 percent of the space heating requirements during the so-called cold month of January.

The second project consists of a commercial-agricultural application of industrial dehydration of food products through the use of solar energy. The purpose of this project, which was conducted in conjunction with TRW and others, was to establish the viability of a solar collector and heat storage system attached to a single tunnel of the Lamanuzzi and Pantaleo (L & P) dehydration facility in Fresno, California. It has been determined that the solar system presently in operation is capable of providing approximately 70% of the total heat requirements of one tunnel of the L & P dehydration facility. Supplemental energy requirements are provided as needed during the winter months. Electricity and fuel account for approximately

12 and 18 percent respectively of back-up energy requirements.

Heat storage for the system is facilitated by a rock pile. When there is insufficient solar radiation, the air which is circulating throughout the system is routed through the rock bed heat storage unit as long as heat is available. Any shortage of heat is automatically made up by the thermostatically controlled burners.

The solar collector is a well insulated box with a covering of thin film glazing. The center section of the box contains a four inch deep passage for the circulation of hot air. The construction of the box is comparable to typical collectors except that it is deeper due to the center air passage space and that it contains no tubing or water conveyance means.

The University is continuing to monitor and improve the dehydration system as it will continue to carry on additional experiments to improve future applications of solar energy.

Solar Energy Incorporated, Riverside, California

Solar Energy Incorporated is a relatively new firm which was established in January 1976. It has been conducting business successfully and growing steadily since that time. The company is primarily a plumbing, heating, and airconditioning installation organization which specializes in energy conservation devices related to the basic services offered. They offer auxiliary solar energy systems for 1) heating swimming pools, 2) heating domestic water, and 3) for heating and airconditioning interior structures. The primary source of their success in the field of solar energy is based on the design, testing, and marketing of a very effective and economical solar energy panel which is identified by the name The Sun Genie. The Sun Genie is rather unique in one very important detail. Most solar panels utilize a glass plate cover to allow the sun's energy to enter. The Sun Genie utilizes a thin polyester panel cover which is treated with a substance called Tedlar. This substance was developed by Du Pont and contains characteristics which prevent deterioration for extended periods of time due to the sun's radiation. The polyester panel is less expensive, is extremely lighter in weight, and provides for radiation absorption approximately the same as glass. The supporting frame of the panel consists of their light-weight aluminum extruded shapes. This facilitates ease of handling as well as construction. The bottom supporting surface of the panel is 4 feet x 8 feet celotex board which carries the aluminum collector fins. The collector fins are extruded to form a flat "V" shape. At the crown of the "V," there is a retainer shaped like a "C." The "C" shape holds the one-half inch diameter copper tubing which transports the water through the system.

The construction of this type of panel provides for a dead air space temperature range (ambient) of up to 180°F. The oven area (inside "V" section) provides for a temperature range (ambient) of up to 210°F.

Mr. Kenneth G. Watts, President of Solar Energy, Inc., has offered his services as either a guest lecturer or as a resource person for curriculum development.

Sunwater Energy Products, El Cajon, California

This company specializes in the installation of energy saving equipment for the purpose of 1) heating domestic water, 2) heating swimming pools, and 3) heating and airconditioning residential and industrial buildings. In addition to offering electronic controls, the company specializes in two types of solar energy panels.

The Pool Collector, recommended for use in heating swimming pool water only, is actually an abreviated version of the Hot Water Collector, a larger, more complex panel consisting of the former plus frame, insulation glass cover, and sheet metal backing. The Pool Collector consists of the bare essentials necessary to allow water to circulate throughout a system of copper pipes while absorbing the heat generated by the sun's energy. The range of efficiency, depending on several factors, varies from 30 to 90 percent, and the maximum operating temperature is 110°F. If the panel operates at 80 percent efficiency, it will be conducting water to a swimming pool at a temperature of 88°F.

The Hot Water Collector though heavier (128 pounds compared to 64 pounds for the Pool Collector) and more complex in construction, has a maximum operating temperature of between 160°F and 210°F. The higher maximum temperatures are obtainable by the use of double glazing and increased thickness of insulation. These two features trap the heat inside the panel and prevent excessive heat loss, thus improving the efficiency of the panel.

In addition to those applications previously mentioned, the Sunwater Energy Products Company has installed solar energy panels for use in greenhouse heating, hydroponics, agriculture, car washes, laundromats, laundries, and miscellaneous commercial and industrial situations where low and medium temperatures were required.

International Solarthermics Corporation, Nederland, Colorado

The above named organization is unique in many ways. First, they do not manufacture anything. Second, they carry on a variety of experiments in the pursuit of information relating to the products of other organizations and third, they are the only organization that was found to market a solar furnace.

The corporation has assembled nonspecialist engineers chosen for their "fluency" in many scientific languages and concern for pratical applications. Each research team, for example, includes a marketing expert who "field tests" the practicality of the product for production and develops practical procurement for assembly. They claim that their research and design engineers operate in the real world as opposed to the vacuum of the typical "white lab."

The solar furnace contains very few characteristics of a "regular" furnace. First of all, the furnace is located outside of a house, not in a house. Secondly, it consists of a 24-gauge galvanized steel frame constructed in the shape of an "A" frame. The base (ground floor) measures approximately 9 feet across and the height of the "A" measures approximately 8 feet, and the length varies from 12 feet to 20 feet depending upon requirements. The base (floor) of the furnace consists of 1/2 inch plywood, 6 inch thick polystyrene foam, and 3/8 inch insulating board. The walls are made of laminated insulating board 3/8 of an inch thick and 3/8 inch thick plywood with 4 inches of polyurethane foam in between. The "sunny" side of the "A" frame consists of solar flat plate collectors. Each collector is comprised of aluminum sheeting, transceiving vanes, and a glass covering that traps heat. Air circulates between the glass and the transceiving vanes and transfers heat to the storage area inside the furance. The inside area is referred to as the heat storage battery. Rock is storred inside the furnace between baffles. It completely fills the structure from floor to peak. No excavation is needed. Through the system of baffels, hot air from the solar collectors is forced by fans through the rock battery. The rocks are heated which provides a storage of heat for future household heating. Without the rock heat storage battery, heat would only be available when the sun was shining. To increase heat absorption, a reflective shield is fastened to the base of the "A" on the side of the collectors. The shield reflects the sun's rays up into the collector face, thus increasing and concentrating energy to the heat trap within the collector. This serves to increase efficiency. When the furnace is not in use (warm summer days), the reflector shield is folded, by means of a hinged connection to the "A" frame, to provide a secure cover for the collectors. When the collectors are covered, the solar furnace is "off."

It is easy to envision any home owner who possesses some simple basic construction skills and a small amount of technical "know-how" constructing a solar furnace such as has been described for home use. It would be an interesting "back yard" project to help cut expenses by conserving energy.

CHAPTER IV

SUMMARY AND CONCLUSION

SUMMARY

Government analysts have predicted large increases in the consumption of oil, natural gas, and coal as well as a rapid increase in nuclear generation. At the same time, with the exception of nuclear energy, these resources are known to be decreasing in available supply. These facts have, of necessity, caused an extensive search for alternate energy sources.

Almost, without exception, utility companies throughout the world and other private enterprises have joined an ever-increasing group of proponents of the utilization of solar energy. Most of the potential use of solar energy has been directed toward the heating of domestic hot water. Equally significant, but more expensive, solar-assisted systems are being refined to facilitate space heating, food drying, air conditioning, and electrical power generation. The flurry of experimental activity in these areas has provided a welcome "shot-in-the-arm" for business and industry, although on a small scale.

A great variety of collectors of solar energy are presently offered to the public. Most are proven to be effective within the limits of design criteria but leave much to be desired in the catagory of applied efficiency. Collectors range from the very complex and expensive to very simple and inexpensive. The general public, the consumer, faces the dilema of cutting costs and conserving energy by selecting a solar system which has no basis for standardized comparison. Local, county, and state building codes, in an effort to protect the consumer, have only recently initiated building codes relative to the installation of solar systems. However, due to a lack of uniformity and/or standards, these codes are less than adequate and provide little or no protection to the consumer.

CONCLUSION

Almost without exception, the visits to institutions engaged in solar energy activities were received with enthusiasm. Except for the limited availability of personnel, the people in all firms visited demonstrated . willingness to share their expertise with the writer. When pertinent data was available, it was given freely by the parties involved.

Available data on solar systems is limited, but is increasing. The International Solar Energy Society of Denver, Colorado, leads the field in compiling significant data. There is evidence that local and state groups are organizing for the purpose of gathering information and promoting interest and knowledge in the utilization of solar energy.

As a result of this report, it has been determined that there is an urgent need for centralized storage of specialized data on the application of solar energy for public use. Present information, so far as can be determined, is specialized to meet the needs of its possessor. Each agency possesses information different than the others and peculiar to their individual product or service. Standardization in any form is non-existant.

In conclusion, it appears certain that employment opportunities relating to the field of solar energy will increase exponentially in the near future. Products and services needed to implement these systems will require the training of skilled technicians in a graet variety of endeavors. The community colleges are best suited to meet this challenge and provide training to meet the needs of this new industry.

A P P E N D I X

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SCHEDULED VISITATIONS

July 5, 1977:	Sundu Company, Anaheim, California General Energy Devices, Santa Ana, California
July 6, 1977:	Atomics International, Canoga Park, California Rho Sigma, Tarzana, California Fred Rice Productions, Van Nuys, California
July 12, 1977:	Arizona State University, Tempe, Arizona Helio Associates, Tuscon, Arizona General Energy Devices, Tucson, Arizona
July 18, 1977:	Colorado State University, Ft. Collins, Colorado International Solarthermics, Nederland, Colorado Environmental Consulting Services, Inc., Bolder, Colorado
July 20, 1977:	Solaron, Denver, Colorado
July 22, 1977:	Solar Industries, Las Vegas, Nevada Solar Systems, Las Vegas, Nevada
July 26, 1977:	Solartec Company, Solano, California Sun Water Company, El Cajon, California
July 27, 1977:	San Diego State University, San Diego, California Solar Applications, Inc., San Diego, California
August 3, 1977:	Cal Poly, San Luis Obispo, California
August 4, 1977:	Solar Access, Santa Cruz, California Fafco, Sunnyvale, California
August 8, 1977:	Henry Mathew, Builder, Coos Bay, Oregon Twin City Builders, North Bend, Oregon
August 10, 1977:	Chico State University, Chico, California