APPLIED SOLAR ENERGY AT THE
SHIRAZ TECHNICAL INSTITUTE

by
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APPLIED SOLAR ENERGY AT THE SHIRAZ TECHNICAL INSTITUTE

Abstract

Factors affecting the application of solar energy and the preliminary design of a solar system to supplement the service hot water system at the Shiraz Technical Institute are described. In addition to the solar energy demonstration, the educational benefits of selected solar projects and laboratory experiments are discussed. An effective, yet expandable, initial installation can be made at reasonably low cost because advantage is taken of architectural features of the buildings and the nature of the conventional service hot water heating system. Opportunities for the future are also briefly considered.
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I. Introduction

A. Factors Affecting Application of Solar Energy

1. Solar Availability

The solar energy flux density normal to the solar beam at a point outside the earth's atmosphere for the mean earth-sun distance is 1.35 $Kw/m^2$. The atmosphere, even in the sun-rich areas such as the U.S. Southwest, reduces this annual mean normal intensity to 0.86 $Kw/m^2$ for 10 hours a day. The U.S. "sunbowl" is mostly between latitudes 30°N and 33°N which in Iran corresponds to an area including Abadan, Kerman, Isfahan and Birjand. Actual local weather conditions can vary considerably from site to site, but for preliminary designs, average data for comparable regions can serve quite well.

Ten years of research in Egypt have shown that the daily total direct and sky radiation upon a south-facing surface at 30° from horizontal varies from about 6470 Kgm cal/m² - day in April to about 5400 Kgm cal/m² - day in January. (Cairo at 30°N). In this location, a one square meter solar heater may heat water from 21°C to 55°C in the amount of about 80 liters per day in January to about 130 liters per day in August.

We will use empirical data for preliminary design considerations at the Shiraz Technical Institute (See Table I). It is clear from these figures that solar energy is quite diffuse and therefore requires substantial collector areas to produce significant amounts of energy compared with that used in a highly industrialized society. Because energy usage has not yet become a keystone in the structure of life in the less industrially developed countries, relatively modest collector areas can be important. Solar energy is spread by nature more or less uniformly over all of Iran. There are advantages in a distributed energy source. It would appear wise, at least in the beginning, to have solar applications in Iran take advantage of this feature. Solar energy by its very nature is available to remote regions without pipelines, motorized transport, or electric power transmission lines. In this context, it must be considered a vital and valuable distributed resource.

2. Capital Investment

Because solar energy is diffuse, large collector areas are required. The first cost of a solar energy system is substantially greater than that of most other energy production or energy conversion systems. Mass production of components can reduce costs, but these component costs have a "floor" set by materials and fabrication costs of essential subcomponents. True, solar radiation itself is free, but money, mineral resources and energy are needed to build the system to take advantage of this free good. Careful consideration must be given to how best to use these resources to produce a net energy gain. Complete solar systems being built in the U.S. today cost between $300 and $900 a square meter, installed.

3. Plant Utilization

The cost effective utilization of any energy plant having a large first cost requires a large plant utilization factor, i.e., use is made of the available output of the plant for the greatest fraction of the available time. Solar heating of buildings alone, for example, does not involve good plant utilization because the requirement for heat only occurs a part of
the year. Moreover, the greatest demand for heat occurs in winter when the available solar energy is least. Solar cooling in summer would have a larger plant utilization factor in Iran, but absorption chilling equipment available today requires higher temperature heat resulting in less efficient operation of typical solar collectors. More efficient evacuated collectors are beginning to appear, but are still very much in the development stage. Service or domestic hot water for buildings, on the other hand, is characterized by a relatively uniform year-round demand, and temperatures required are lower than for heating or cooling. Solar energy can be used to preheat the cold water supply with conventional heaters providing the desired final temperature thereby lowering the collection temperature of the collectors which increases their efficiency. For schematic design purposes the architects and engineers have estimated domestic hot water consumption for the Institute at 95,000 liters/day. For these reasons, solar water heating makes the most economic sense for the near term.

4. Operation and Maintenance

A major unknown in novel systems is what operation and maintenance costs will be. Early experience with many systems in the U.S. has not been good. Collectors especially have been plagued with malfunctions. Many of these problems have been solved, but the lesson to be learned from this experience is to try the simplest systems first. We have had the longest and most satisfactory consumer experience with solar water heaters.

II. A Solar Supplement for Service Hot Water in the Institute

A. Description of the Conventional System

The domestic hot water system recommended by the design development architects consists of dual storage type generators complete with immersion coil and fully automatic controls and safety components. The heating coils will be supplied with high temperature hot water (at 110°C) from the central heating system which is circulated back to the main system through a constant-running, pumped by-pass arrangement. Each storage section is to have internal circulation and internal diffusers to minimize stratification of the stored water. The hot water will be piped to all buildings via the tunnel system and connect to all fixtures and equipment requiring same, and be circulated back to the generating plant to insure a constant-use temperature. (Figure 1)

The capacity of each of the two heaters is to be 2300 liters per hour of water heated from 4.44°C to 60°C; the outlet to be controlled within ± 15°C of the selected temperature when supplied with high temperature water from the central heating system (110°C). According to the above rating, each unit must have the capacity to transfer 128,000 kilocalories/hour to the water. The storage section is to contain 4900 liters of water. The total storage capacity of the units is 9800 liters.

B. Integration of a Demonstration with the Conventional System

The domestic hot water system recommended in the design development offers an excellent opportunity to integrate, at minimum cost, a solar supplement for water heating. We have the opportunity to start with a modest system that can effectively supplement the hot water supply system and plan for expansion of the system as experience is gained with operation and demand profiles of actual hot water use in the various buildings of the Institute can be determined.
Actual demand profiles are far more important to the solar system design than to the
design of heaters using conventional fuels. In the latter case, because the supply of fuel
can be controlled to meet the demand for energy, it is only necessary to provide for peak
anticipated demand in sizing the equipment. Engineering practice, particularly in design
development, allows a sizeable safety factor.

We have no control over the sun. We must collect solar energy when it is available
and either use it immediately or provide some form of storage. Both collection and storage
involve large capital costs. It would be foolish to design a collector that would provide more
energy than could be immediately used or economically stored. Worse yet, if we had to provide,
at additional capital cost, heat dumps to dispose of the surplus to avoid overheating the sys-
tem on peak solar days.

It is possible to control the amount of energy collected. The simplest approach is to
provide a removable cover for the collector. A more complex method is to control, in one way
or another, the heat losses of the collector.

These factors are taken into account in the conceptual design of the solar installation.

C. Conceptual Design and Estimated Cost

1. Structural

The structural design of the skylighted roofs offers ideal locations for unobtrusive
installation of solar collectors. The 45° slope of the southerly face of the skylight
structures is close enough to an ideal slope (about 30° from horizontal) to make flush mount-
ing of the collector panels a practical alternative. This method of mounting solar panels
has the additional advantage of reducing collector thermal loss which would be exacerbated
if wind and cold outside air were permitted to reach the back of the panels. About 2000 square
meters of skylight roof area is in the design concept (See Figure 2). There is adequate space
for future expansion.

The initial installation should be made on a building near the portion of the hot water
loop most distant from the power station. In this position, the solar system can make up
for thermal losses resulting from the continuous circulation of hot water, in addition to
supplying a portion of the hot water required by the building.

2. Hot Water Circulation

The continuous circulation feature of the hot water supply will permit us to
operate the solar system circulation from this loop without additional pumps. An appropriate
fraction of the circulating hot water can be diverted through the collectors for additional
heating by solar energy. In this system, the storage capacity of the conventional system
will also be utilized by the solar units thus requiring no additional storage. Any solar
heat added in this way will lessen that required from the central power plant (See Figure 3).

3. Control System and Freeze Protection

The solar control system will monitor collector water temperature and will divert
water through the collector only when this temperature exceeds that in the loop. When solar
hot water is available, the control of the hot water temperature of the conventional system
will be systematically set to the low side of the ±15°C temperature range. To prevent
freezing of water in the collectors on those rare occasions when the danger exists, a small
quantity of the water in the loop will be diverted through the collector to maintain the water
temperature in it above freezing. It is also possible that freezing can be prevented by
circulating water in a loop through the collector alone (See Figure 3).

4. Solar Collector Location

Two locations are recommended for an initial solar collector installation, the roof of the manufacturing processes and computer building and that of the library building. Both of these locations are near extremities of the hot water circulation loop and have sufficient areas on the south slopes of the skylights to support the collector area envisaged. We have conferred with the conceptual design architects who anticipate no roof loading problems with the installation of solar collectors in this fashion.

5. Collector Protection

The effective area of the installed collectors can be increased with flat reflectors installed at the base of the collector panels and projecting over the flat roof. These reflectors, if hinged at the bottom of the collector panels, could serve as a cover for the collectors when the system is not in use or if it is desired to make the collector inoperative for some other reason. We recommend the use of covers for the collector panels rather than a "heat-dump" heat exchanger to avoid system overheating. Covers are less expensive and provide more positive control by regulating the energy collected rather than the disposition of the excess. In the testing and evaluation of collector performance it is often useful to compare the operation of a covered collector with one that is uncovered.

6. Heat Loss Estimates for the Hot Water Loop

From the conceptual design, we have made an estimate of the heat loss and the circulating pump rate for the domestic hot water loop. We estimated a loss of 2.3 Kcal/meter-hr in the 0.1m supply and return piping with 1.50cm insulation. A loss of 575 Kcal/hr in a pipe loop length of 250 meters is expected. From this, we estimated that a 10 to 20 liters/min circulating pump would be used.* A 10 liter/min circulation rate would be adequate for up to 20m² of collector area.

7. Collector Size

As an initial installation, we recommend consideration of 10 square meters of collector (1/2% of estimated available area). This area may seem small by comparison, but it is not necessary to build a swimming pool to get one's feet wet.

In the future, the area can be increased by the addition of reflector/covers or by the addition of panels. Ten square meters can be made up of 5 panels of 2 square meters each, not an uncommon size for commercially available collector panels. These panels would be installed flush with the south slope of the skylight roof, thereby having an angle of 45° from horizontal.

8. Collector Specification

Because these collectors will be connected in the potable water supply system, the materials used in the fabrication of the piping should be compatible with the hot water plumbing. This is expected to require copper piping throughout to avoid corrosion. The collector panels and piping would also be required to withstand the same pressures encountered in the hot water piping.

9. Estimated System Performance

If we make the conservative assumption that on the average 5000 Kcal/m² day of

*In the event more pipe insulation is used, or the hot water temperature is less than 60°C (140°F) these values would be reduced accordingly.
solar energy falls on the collector which operates at an efficiency of 50%, the system would utilize 25,000 Kcal per day of solar energy in heating domestic hot water. If the water circulation system is operated only 12 hours a day, the estimated loop loss would be 6900 Kcal/day. The solar system would contribute 18,100 Kcal/day in excess of the loop loss. If the water circulation system is operated 24 hours a day, the estimated loop loss would double*. The 25,000 Kcal per day would raise the temperature of 1000 liters of water a day by 25°C. This is only about 1% of the 95,000 liters/day design level of hot water consumption, but the system is large enough to tell us a lot about effective utilization of solar energy at the Shiraz Technical Institute.

It is unlikely that the supply water temperature in Iran is ever at temperatures below 15°C. Therefore, the design temperatures 4.5°C to 60°C commonly used in the U.S. would ensure a substantial safety factor in the sizing of the conventional equipment. It is quite conceivable that it would be unnecessary to use both heaters most of the time and especially when the solar supplementary system is employed.

10. Estimated System Cost

Until more design detail is done, it is difficult to estimate the cost of this solar installation accurately. Because there will be no need for a storage tank or circulating pump, we estimate the cost of the installation in the middle of the range quoted earlier ($300-$900/m²) at $600/m². The 10 square meter system is therefore estimated to cost $6000 installed.

D. Solar System Growth Potential

The architectural design of the Institute is ideally suited to the installation of large areas of solar collectors. Because of the way the skylighting is done, it appears that mounting additional collectors after completion of the buildings will not be very expensive. Solar collector panels and their manufacturers are in a very evolutionary stage today with new developments occurring frequently. Fortunately, it is not necessary to install a large system initially to evaluate the potential of solar energy as an alternative or supplementary source. For this reason, a rather modest installation is recommended for the Institute itself, and portable unitized solar water heaters suggested for classroom use. Reflectors are suggested as the least costly way of increasing the installed collector area. The fact that reflectors can serve as covers is an added benefit. If additional collectors are installed, we recommend that they be located at another spur of the hot water loop.

III. Education for Applied Solar Energy in Iran

Solar energy is replete with opportunities to learn-while-doing at a technical institute. There are the physics of radiation, emission and absorption; the thermodynamics involved in heat transfer -- conduction, convection, and radiation; the fluid dynamics of the thermosyphons, pumped liquids and forced air; the electronics of modern control systems. Practical skills involved include sheet metal work, pipe fitting and plumbing, thermal insulation installation, glazing, and control system installation and maintenance.

*The operation of the domestic hot water circulation only during hours of occupancy is recommended as a conservation measure.
A. A Simple Solar Calorimeter

Student fabrication of a small solar calorimeter of a design comparable to that shown in Figure 5 is suggested as an excellent educational tool. Not only will manual skills be developed in its construction, but also the solar calorimeter can be used to perform experiments in heat transfer, collector efficiency, and specific site evaluation. When carefully calibrated the solar calorimeter can serve as an accurate, portable secondary standard. The system for field use can be made extremely simple, hence especially useful for solar site evaluation in remote areas.

B. Solar Hot Water Heating

Because of the simplicity of solar water heating systems and their general utility throughout the country, we recommend that work with, and study of, these systems be made a part of the Institute's curriculum. There are a number of systems offered commercially today in the U.S., Australia, Japan, and in Europe. All the essential components of water heating systems are also available to permit the assembly of special purpose units. A self-contained solar water pre-heater that can provide hot water for an average family of three is available now at a cost of about $800*. The unit employs a 1.35m$^2$ collector. The cost of those available from other suppliers is comparable.

IV. Some Opportunities for the Future

A. Solar Heating and Cooling

Solar heating of buildings is as technically feasible as the heating of domestic hot water. Temperatures required for space heating are comparable with those for hot water heating (60°C). A low plant utilization factor makes solar space heating less cost effective at the present time. Progress in this area can be followed closely in connection with actual work with domestic hot water heaters.

Solar cooling presents more difficult technical problems. Most solar cooling is done with absorption refrigeration of chiller units. Today's commercial absorption units require higher input temperature heat for efficient and/or full capacity operation. Improvements are being made in commercial units and we have seen progress with novel processes in the laboratory, e.g., absorptive heat pumps using zeolite.

B. Solar Refrigeration for Food Preservation

1. Night Sky Radiation (11)

In desert regions substantial cooling can be had from radiation into the clear night sky. This is particularly true at high altitudes characteristic of some areas of Iran. It is possible to freeze ice under such conditions. The combination of night sky radiation cooling with thermal storage is an area of future investigation that could have great promise for remote areas.

2. Sorption Refrigeration

There are materials that have great affinity and storage capacity for certain liquids. Silica gel and water, and zeolite and water are examples. In the sorption process, be it absorption or adsorption, we have what is in effect, a pump. The pump cannot work

*Aquarius I; from Kalwall Corp., Manchester, N.H.
continuously, of course, and must be recycled or dried when its capacity to adsorb or absorb the working fluid is reached. The application of heat is a convenient way to recycle the pump. It can be done with solar heat. This "heat pump" is still in the laboratory, but does hold promise for application to the freezing of ice and the refrigeration of food in remote areas with no source of energy required other than the sun. (14)

C. Solar Distillation for Potable Water Recover and Waste Water Recycling

We have considerable experience in the use of solar distillation units for the production of potable water from salt or brackish water. Thus far, the costs of solar stills have been too high to be competitive with other distillation methods in all but unusual circumstances. Yet in areas where the sun is ample and potable water scarce, the challenge is great. The use of solar stills for the recovery of potable water from waste water also offers interesting possibilities and should be explored further. Efforts of this kind are a logical extension of current plans to recover, treat, and use for purposes of watering plants, sanitary and storm effluent at the Shiraz Technical Institute.

V. Conclusion

It is the objective of this proposal to provide the Shiraz Technical Institute with a demonstration of a practical application of solar energy to meet some of the energy needs of institutional buildings. In addition, students will have the opportunity for "hands-on" experience with solar systems with real potential for application throughout Iran.

The growth potential in both the demonstration and educational areas is great. As the applications of solar energy evolve, and new developments emerge, the Shiraz Technical Institute can prepare its students for important roles in conservation and alternative energy.

Bibliography


Abstract: A single-glass, flat-plate solar collector for air heating is analyzed for an optimum tilt angle of 45° for Shiraz (29°36'N latitude, 52°32' E longitude, and elevation of 4500 ft). The absorbed and utilized solar energy, as well as the collector outlet air temperature, the glazing, and the blackened plate temperatures, are determined with respect to the incident solar energy, parametric with collector inlet air temperatures and flow rates and outside air temperature.

A 10 ft² collector and an 8 ft³ rock storage are built to experimentally verify the analysis and obtain cost estimates. A 500 ft² single-story building is considered for solar heating and economic evaluations. Based on an annual interest rate of 8 percent amortization of the solar heating equipment over 15 yr. electrical energy costs of 3¢/kWh, and fuel costs of $1.10 per 10^6 B.t.u., the optimum collector area which results in minimum annual operating costs (of the solar heating system and the auxiliary heating unit) is determined. A net saving results because solar heating is employed. The feasibility study is extended to eleven other Iranian cities. It is found profitable to employ solar heating in cities with low annual rainfall and relatively cold winters. An effective evaporative cooling is obtained by spraying water over the rock storage during the summer.

### TABLE I

**SOLAR RADIATION DATA HELWAN OBSERVATORY, UAR**

(29°52'N, 31°21'E)

Daily total solar radiation on a south-facing surface at angle $\phi$ tilt to horizontal in kilocalories/meter$^2$.

<table>
<thead>
<tr>
<th>MONTH</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>(Ave)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\phi = 30^\circ$</td>
<td>5300</td>
<td>5480</td>
<td>5750</td>
<td>5900</td>
<td>5750</td>
<td>5750</td>
<td>5650</td>
<td>5650</td>
<td>5750</td>
<td>5650</td>
<td>5250</td>
<td>5000</td>
<td>(5570)</td>
</tr>
<tr>
<td>$\phi = 45^\circ$</td>
<td>5600</td>
<td>5650</td>
<td>5750</td>
<td>5340</td>
<td>5000</td>
<td>4850</td>
<td>4900</td>
<td>5150</td>
<td>5500</td>
<td>5700</td>
<td>5600</td>
<td>5350</td>
<td>(5570)</td>
</tr>
<tr>
<td>$\phi = 60^\circ$</td>
<td>5700</td>
<td>5550</td>
<td>5200</td>
<td>4500</td>
<td>3950</td>
<td>3800</td>
<td>2750</td>
<td>4200</td>
<td>4850</td>
<td>5400</td>
<td>5500</td>
<td>5450</td>
<td>(4740)</td>
</tr>
</tbody>
</table>

Daily hours of sunshine
- 6.9
- 8.2
- 9.1
- 10.4
- 12.1
- 13.2
- 13.0
- 12.4
- 11.3
- 9.9
- 8.6
- 7.5

% of possible sunshine
- 66
- 73
- 76
- 82
- 88
- 94
- 93
- 93
- 92
- 87
- 80
- 73

**Average Annual Solar Radiation**

1. Computed as $365 \times$ average daily radiation:
   - $\phi = 30^\circ$ -- 2,033,305 kilocalories/meter$^2$
   - $\phi = 45^\circ$ -- 1,960,050

2. Computed as $\sum$ average monthly radiation: Ave. Monthly = days in month x ave. daily.
   - $\phi = 30^\circ$ -- 2,034,190
   - $\phi = 45^\circ$ -- 1,957,850

**NOTE:** 1 langley = 1 cal/cm$^2$ = 10K cal/m$^2$
FIG. 2. TYPICAL SKYLIGHT STRUCTURE

FIG. 3. DESIGN CONCEPT--SOLAR ASSISTED DOMESTIC HOT WATER

- Controller
- Tc sensors
- Possible freeze protection circulation loop
- Diverter valves
- Control circuits
- Anticipator signal to conventional DHW system
- Both valves may not be needed
FIG. 4. THERMOSYPHON CIRCULATION SYSTEM

FIG. 5. EQUIPMENT FOR SITE OR COLLECTOR EVALUATION
APPENDIX I

Partial List of Solar Equipment Suppliers and Installers

The solar system and component manufacturers and installers listed here are representative only. The list is neither complete nor comprehensive and the inclusion of any company is not to be taken as a recommendation of the company or its product. The list, derived from three different sources, does give an indication of the diversity of interest in the field and is included for general information.

The Energy Research and Development Administration has attempted a comprehensive catalog of solar equipment suppliers. The catalog entitled, "Catalog on Solar Energy Heating and Cooling Products" ERDA-75, October 1975 is available from:

ERDA Technical Information Center
Post Office Box 62
Oak Ridge, Tennessee 37830
For additional information on copper solar collector systems you may wish to contact one or more of the following manufacturers:

Ametek
Power Systems Group
One Spring Avenue
Hatfield, Pennsylvania 19440
Attn: Mr. John Bowen
215/822-2971

Hughes Supply, Inc.
P.O. Box 2273
Orlando, Florida 32802
Attn: Mr. Jim Holland
305/841-4710

Bright Industries Sun Products Inc.
1900 N.W. 1st Court
Boca Raton, Florida 33432
Attn: Mr. Lee Gordon
305/391-4686

Largo Solar Systems, Inc.
2525 Key Largo Lane
Fort Lauderdale, Florida 33312
Attn: Mr. Ronald T. Hannivig
305/583-8090

Capital Solar Heating, Inc.
376 N.W. 25th Street
Miami, Florida 33127
Attn: Mr. Ronald Saifman
305/576-2380

National Solar Company
2331 Adams Drive, N.W.
Atlanta, Georgia 30318
Attn: Mr. J.B. Franklin
404/352-3478

Consumer Energy Corporation
4234 S.W. 75th Avenue
Miami, Florida 33155
Attn: Mr. Bernard Goodman
305/266-0124

Olin Corporation (Brass Group)
Roll-Bond Division
East Alton, Illinois 62024
Attn: Mr. J.I. Barton
618/258-2443

Daystar Corporation
41 Second Avenue
Burlington, Massachusetts 01803
Attn: Mr. Charles A. Pesko, Jr.
617/272-8460

P.P.G. Industries, Inc.
Solar System Sales
One Gateway Center
Pittsburgh, Pennsylvania 15222
Attn: Mr. N.M. Barker
412/434-3552

Dick Mills
Division of Airtron Inc.
15286 U.S. Highway 19 South
Clearwater, Florida 33516
Attn: Mr. Kenneth Listle
813/531-3581

Revere Copper and Brass Incorporated
Research and Development Center
P.O. Box 151
Rome, New York 13440
Attn: Mr. W.J. Heidrich
315/338-2022

General Energy Devices, Inc.
2991 West Bay Drive
Largo, Florida 33540
Attn: Mr. Ian Morgan
813/586-1142

R.M. Products
5010 Cook Street
Denver, Colorado 80216
Attn: Mr. Don Erickson
303/825-0203
W.R. Robbins & Son
1401 N.W. 20th Street
Miami, Florida 33142
Attn: Mr. I.E. Simone
305/325-0880

Semco, Inc.
1091 S.W. 1st Way
Deerfield Beach, Florida 33441
Attn: Mr. David B. Aspinwall
305/427-0040

Solar Development Inc.
4180 Westroads Drive
West Palm Beach, Florida 33407
Attn: Mr. Bill Rand
305/842-8935

Solar Energy Products Inc.
722 S. Main Street
Gainesville, Florida 32601
Attn: Mr. Jack Ryals
904/377-6527

Solar Heating & Air Conditioning Systems
1644 49th Street N.
Clearwater, Florida 33750
Attn: Mr. C.H. Breckenridge
813/577-3961

Solar Systems Inc.
54 Ervin Street
Belmont, North Carolina 28012
Attn: Mr. Robert Kincaid
704/825-8416

Sun Harvesters, Inc.
211 North East 5th Street
Ocala, Florida 32670
Attn: Mr. Dick Housteman
904/629-0687

Sun sav Incorporated
250 Canal Street
Lawrence, Massachusetts 01840
Attn: Mr. P. Ottmar
617/686-8040

Sunworks, Division of Enthone, Inc.
An ASARCO Subsidiary
P.O. Box 1900
New Haven, Connecticut 06508
Attn: Mr. Floyd Perry
203/934-8611

United States Solar Systems, Inc.
P.O. Box 48695
Los Angeles, California 90048
Attn: Mr. Albert F. Lombardo
213/851-2833

Universal Solar Energy Company
1802 Madrid Avenue
Lake Worth, Florida 33461
Attn: Mr. R.F. Schenck
305/586-6020

Universal 100 Products
Southern Lighting Mfg. Co.
501 Elwell Avenue
Orlando, Florida 32803
Attn: Mr. Glenn O'Steen
305/894-8851

NOTICE: This list has been prepared for the use of professionals such as architects, interior designers, and building contractors as an informative source reference for copper solar collectors. CDA assumes no responsibility or liability of any kind in connection with this solar collector list and makes no representations or warranties of any kind with respect to any of the products listed herein.
SOLAR WATER HEATER MANUFACTURES

(This is only a partial list and does not indicate an endorsement of any of the manufacturers by us).

FLORIDA SUPPLIERS

1. Beutel's Solar Heater, Inc.  
   1527 North Miami Avenue  
   Miami, Florida 33136  
   305-822-6268

2. D & J Sheet Metal Co.  
   10055 NW 7th Avenue  
   Miami, Florida  
   305-325-7033

3. Solar Power Company  
   42 Edna  
   Route #4  
   Port Richey, Florida

4. Youngblood Co., Inc.  
   1085 NW 36th Street  
   Miami, Florida 33127  
   305-635-2501

5. McDonald Window Sales and Service  
   3003 NE 19th Drive  
   Gainesville, Florida 32601

   9951 SW 38th Street  
   Miami, Florida 33142

7. Deko-Labs (Temperature controllers for pump only)  
   Box 12841  
   Gainesville, Florida 32604

8. Solar Energy Systems  
   1605 W. Cocoa Blvd.  
   Cocoa, Florida 32922  
   305-632-5988 or 305-452-2628

   2185 Sherwood Drive  
   South Daytona, Florida 32019

10. Superior H.J. Service  
    Post Office Box 706  
    Holly Hill, Florida 32017  
    904-253-6466

FOREIGN SUPPLIERS

1. Silvas Limited  
   7 West 14th Street  
   New York, New York 10011  
   Imported from Israel

2. Beasley Industries PTY Ltd.  
   Bolton Avenue, Devon Park  
   SOUTH AUSTRALIA

3. Amcor Export Co., Ltd.  
   Post Office Box 2850  
   Tel Aviv, ISRAEL

4. Hitachi Hi-Heater  
   Hitachi Chemical Co., Ltd.  
   4, 1-Chome  
   Marunouchi, Chiyoda-Ku  
   Tokyo, JAPAN

A-3
SOLAR HEATING
MANUFACTURERS AND INSTALLERS

Solar Energy Systems
350 South Brayton Road
Tiverton, R. I. 02878
401-624-4943

Sol-R-Tech
The Trade Center
Hartford, Vermont 05047
802-295-9343

Sun Systems, Inc.
P. O. Box 347
Milton, Massachusetts 02186
617-268-8178

Sunworks, Inc.
669 Boston Post Road
Guilford, Connecticut 06437

Sun-Sav, Inc.
250 Canal Street
Lawrence, Massachusetts 01840
617-686-8040

Day Star
41 Second Avenue
Burlington, Massachusetts 01803
617-272-8460

Solaron Corporation
4850 Olive Street
Denver, Colorado 80022

PPG Industries
1 Gateway Center
Pittsburgh, Pennsylvania 15222

Installer - Tucker & Rice, Inc.
451 Southbridge Street
Worcester, Massachusetts
617-755-1214

Installer - R. S. Robinson, Jr., Inc.
1105 Commonwealth Avenue
Boston, Massachusetts
617-783-1072

Installer - R. P. Holmes Corporation
97 Border Street
West Newton, Massachusetts
617-527-0682

Installer - R. I. & So. Eastern Connecticut
General Alternatives
10 Water Street
Mystic, Connecticut 06355
203-536-7811

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