APPLIED SOLAR ENERGY AT THE
SHIRAZ TECHNICAL INSTITUTE

by

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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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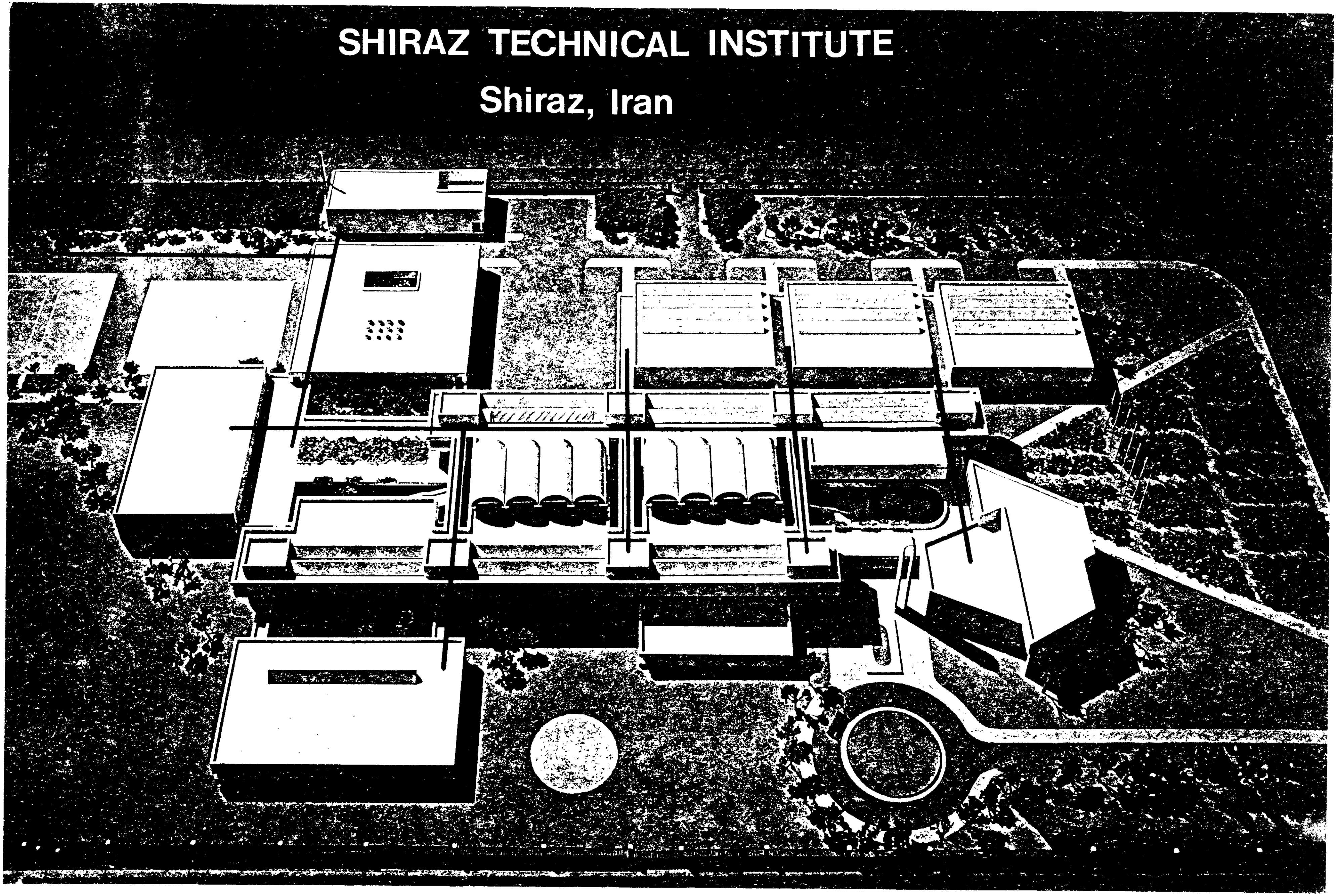

Fig. 1. Design layout of the Shiraz Technical Institute showing the domestic hot water distribution loops (———)

APPLIED SOLAR ENERGY AT THE SHIRAZ TECHNICAL INSTITUTE

James W. Meyer

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/m^2 - day in April to about 5400 Kgm cal/m^2 - 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[3] 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 system 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 mounting 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 $\pm$ 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 $20m^2$ 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 $Kcal/m^2$ 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/m^2) at \$600/m^2. 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.

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11. Picha, K.G. and J. Villanueva, "Nocturnal Radiation Measurements", Solar Energy, Vol. 6, No. 4, 1962 pp. 151-154.

    Parmelee, G.V. and W.W. Aubele, "Radiant Energy Emission of Atmosphere and Ground", Heating, Piping & Airconditioning (ASHVE Journal), 1951, p. 123.

    Bar-Cohen, A. and C. Rambach, "Nocturnal Water Cooling by Skyward Radiation in Israel", Paper No. 749011, Proceedings of the 9th Intersociety Energy Conversion Engineering Conference, San Francisco, CA. Aug. 26-30, 1974.

12. F. de Winter and J.W. de Winter "Description of the Solar Energy R&D Programs in Many Nations", Report SAN/1122-76/1 (ERDA), Atlas Corporation, February 1976.

13. Bahadori, M.N., "A Feasibility Study of Solar Heating in Iran", Solar Energy, Vol. 15, pp. 3-26, 1973.

    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 ft^2 collector and an 8 ft^3 rock storage are built to experimentally verify the analysis and obtain cost estimates. A 500 ft^2 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.

14. Bahadori, M.N. and F.E. Edlin, "Improvement of Solar Stills by the Surface Treatment of Glass", Solar Energy, Vol. 14, pp. 339-352, 1973.

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 ϕ tilt to horizontal in kilocalories/meter^2.

MONTH

	1	2	3	4	5	6	7	8	9	10	11	12	(Ave)
ϕ = 30°	5300	5480	5750	5900	5750	5750	5650	5650	5750	5650	5250	5000	(5570)
ϕ = 45°	5600	5650	5750	5340	5000	4850	4900	5150	5500	5700	5600	5350	(5570)
ϕ = 60°	5700	5550	5200	4500	3950	3800	2750	4200	4850	5400	5500	5450	(4740)
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 x average daily radiation:
   - ϕ = 30° -- 2,033,305 kilocalories/meter^2
   - ϕ = 45° -- 1,960,050
2. Computed as Σ average monthly radiation: Ave. Monthly = days in month x ave. daily.
   - ϕ = 30° -- 2,034,190
   - ϕ = 45° -- 1,957,850

NOTE: 1 langley = 1 cal/cm^2 = 10K cal/m^2

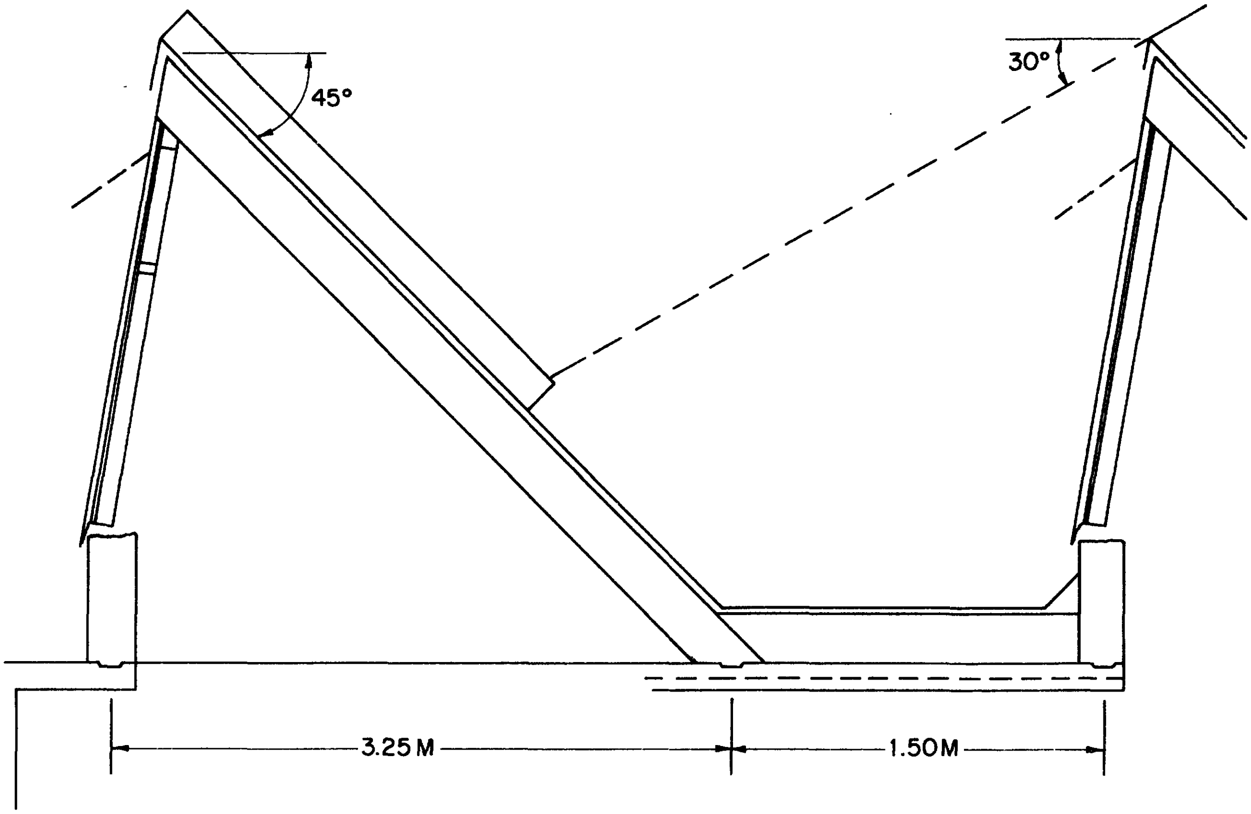

FIG. 2. TYPICAL SKYLIGHT STRUCTURE

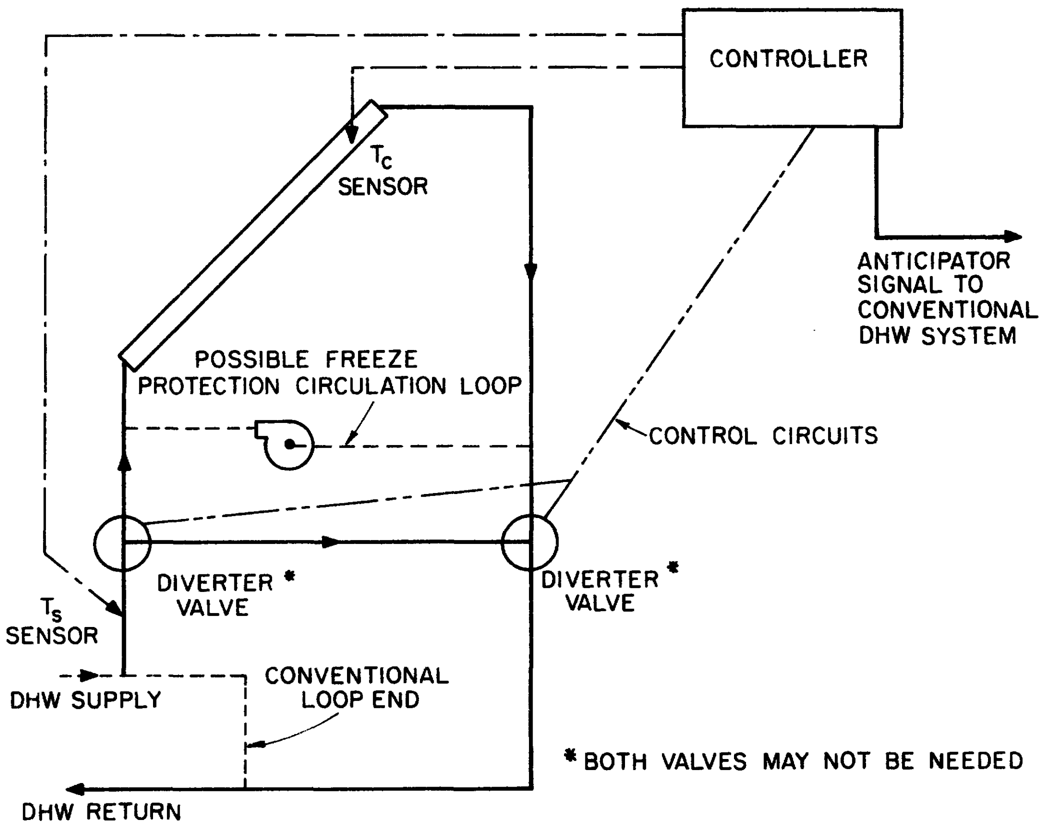

FIG. 3. DESIGN CONCEPT--SOLAR ASSISTED DOMESTIC HOT WATER

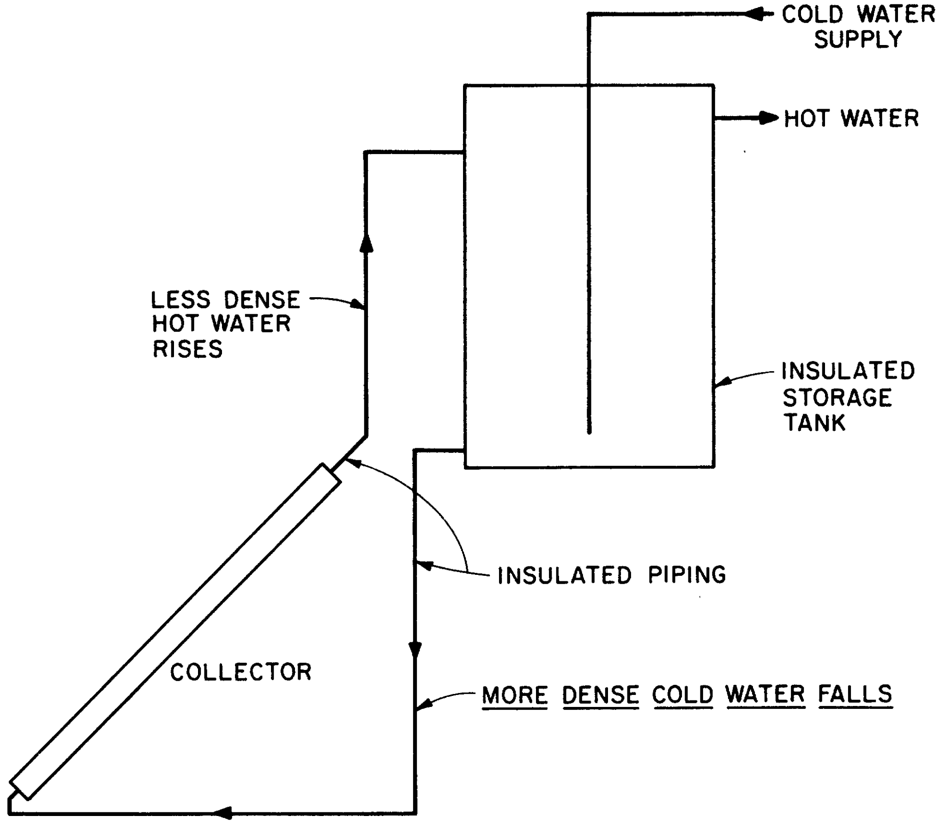

FIG. 4. THERMOSYPHON CIRCULATION SYSTEM

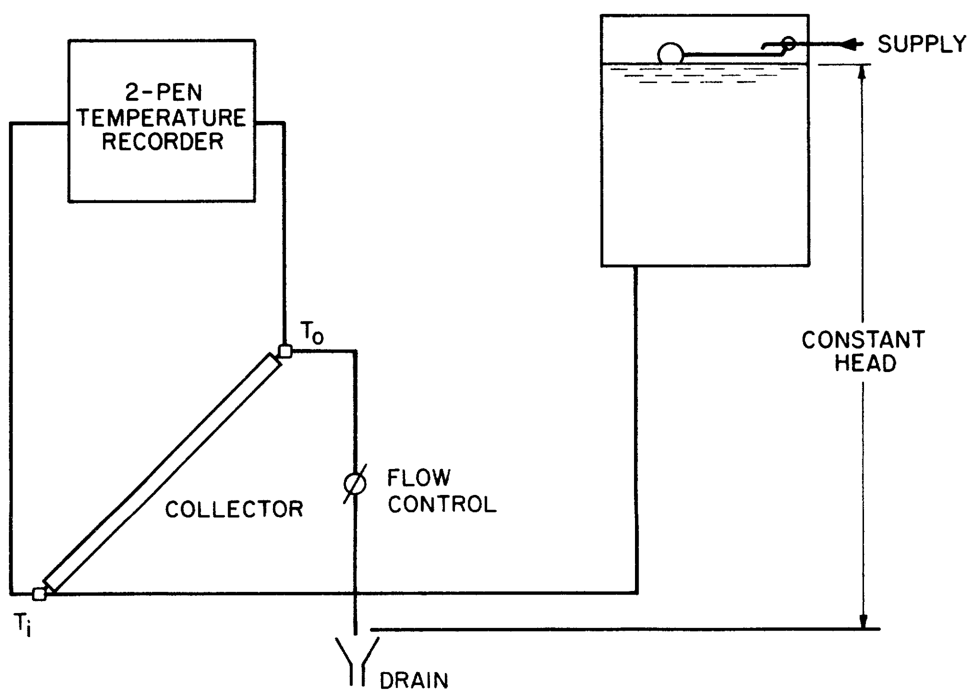

FIG. 5. EQUIPMENT FOR SITE OR COLLECTOR EVALUATION

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

copper development
association inc.

405 Lexington Avenue, New York, N.Y. 10017 COPPERDEV NEW YORK (212) 953-7300

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

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

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

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

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

Dick Mills
Division of Airtron Inc.
15286 U.S. Highway 19 South
Clearwater, Florida 35516
Attn: Mr. Kenneth Listle
813/531-3581

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

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

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

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

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

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

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

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

Sol-Ray, Division of
Unit Electric Control
130 Atlantic Drive
Maitland, Florida 32751
Attn: Mr. Maurice S. Stewart
305/831-1900

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
12554 49th Street No.
Clearwater, Florida 33520
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

Sunsav 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

6. Solar Water Heater Co.
   9951 SW 38th Street
   Miami, Florida 33142

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

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

9. J & R Simmons Const. Co.
   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

SOLAR HEATING

MANUFACTURERS AND INSTALLERS

Manufacturer	Installer
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	Installer - Tucker & Rice, Inc. 451 Southbridge Street Worcester, Massachusetts 617-755-1214 <u>R.I. & So. Eastern Connecticut</u> General Alternatives 10 Water Street Mystic, Connecticut 06355 203-536-7811
Sun-Sav, Inc. 250 Canal Street Lawrence, Massachusetts 01840 617-686-8040	
Day Star 41 Second Avenue Burlington, Massachusetts 01803 617-272-8460	Installer - R. S. Robinson, Jr., Inc. 1105 Commonwealth Avenue Boston, Massachusetts 617-783-1072
Solaron Corporation 4850 Olive Street Denver, Colorado 80022	Installer - McKinley Engineering, Inc. 10 Rice Street Sudbury, Massachusetts 617-443-9124
PPG Industries 1 Gateway Center Pittsburgh, Pennsylvania 15222	Installer - R. P. Holmes Corporation 97 Border Street West Newton, Massachusetts 617-527-0682

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