DOE/RL/01830-T3

MASTER

PHOTOVOLTAICS INDUSTRY
PROFILE

U.S. Department of Commerce
International Trade Administration

and

U.S. Department of Energy
Conservation & Solar Energy

October 1980

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INTRODUCTION

This industry profile for photovoltaic solar-powered electricity generation systems is the result of a joint effort of the Department of Commerce, the Department of Energy, the Solar Energy Industries Association, the Solar Energy Research Institute and the Battelle Pacific Northwest Laboratories. It has been prepared as part of a series of Department of Commerce industry profiles designed for U.S. overseas Commercial Offices, Trade Centers, International Marketing Centers and other organizations involved in the promotion and facilitation of U.S. exports.

Since this is the first attempt to provide an operational description of the status of this comparatively small but rapidly growing U.S. export industry, much of the information provided here is necessarily tentative or incomplete. However, it is expected that this document will prove useful in initial efforts to promote this expanding industry. Updates of this document will be provided as this market develops.

Additional copies of this profile can be obtained by writing to:

Photovoltaic Industry Profile
Attn: Thomas G. West
International Division
Solar Energy Research Institute
1617 Cole Boulevard
Golden, Colorado 80401

or

Photovoltaic Industry Profile
Attn: Raymond L. Watts
Battelle Memorial Institute
2030 M Street, N.W.
Washington, D.C. 20036

I. PRODUCT LIST BY SIC NUMBERS & B SCHEDULE CODE

There is one recommended Standard Industrial Classification (SIC) code for all photovoltaic power generation devices: 3674992 (Solar Cells); under the generic category, Other Semiconductor Devices (36749xx). Two other SIC codes may sometimes be used but are not recommended: 3674993 (Other Infrared Detectors; Photoconductive Cells; Photovoltaic Devices; Photodiodes; Photoelectric Magnetic Devices; etc.) and 3621475 (Other Electric Generators, including wind driven types). The B Schedule Code for PV is 687.6055 (Solar Cells).

II. PRODUCT LIST BY FUNCTION

Product classes for photovoltaic devices and systems currently available in the market include:

- . Panel Assemblies -- produce sun synchronous DC electric power
- . Panels and Inverters -- produce sun synchronous AC electric power
- . Panels and Motors -- produce sun synchronous rotary motion
- . Power Packs (including storage) -- supplies power on demand (AC/DC)
- . Home Building Electrical Power Systems -- may include accessory products
- . Small Community or Industrial Power Systems -- produce and distribute power to multiple structures for remote villages, mining operations, plantations and other facilities
- . Packaged Products -- provide specific functions such as
 - Micro irrigation, pumping
 - Grain mills and food production machinery
 - Refrigeration
 - Area lighting
 - Vent fans
 - Navigation aids
 - Safety and security systems
 - Corrosion protection
 - Electric fencing for farm animals
 - Microwave repeaters and telemetry
 - Educational television and radio systems
 - Remote sensing and recording devices
 - Radio communication systems
 - Calculators, watches, toys and other consumer goods
- . System Components
 - Cells, panels, arrays

- Power conditioning devices such as inverters, charge and discharge controllers, regulators
- Energy storage devices such as batteries, eutectic salts, storage basins
- Motors
- . Accessory Products -- high efficiency AC and DC appliances such as:
 - Flourescent lights
 - Refrigerators
 - Pumps
 - Fans
 - Televisions, radios
 - Other sensing, recording and transmission devices

III. PRINCIPAL END-USER INDUSTRIES

Photovoltaic systems are currently supplying electricity for a wide variety of applications where small amounts of reliable, essentially maintenance-free power is required in remote areas. These systems are being used for corrosion protection devices, electric fencing, microwave repeaters, water pumps, navigational aids, remote sensing and data transmission devices. More recently these systems are beginning to be used in villages and small commercial/industrial settlements as photovoltaic systems have become economically competitive with 1-5 kilowatt diesel and gasoline-driven electric generators.

Principal industrial sectors where these systems are coming into use are listed below. For the photovoltaic applications currently seen as appropriate to each of these sectors, see table provided in Section X.

- . Agricultural Machinery & Equipment
- . Air Conditioning & Refrigeration Equipment
- . Audio-Visual Equipment & Educational Training
- . Building Supplies & Fixtures
- . Chemical & Petrochemical Industries
- . Consumer Goods, Sporting Goods, etc.
- . Energy Systems
- . Forest Industries Equipment
- . Marine Industries Equipment
- . Medical Instruments & Equipment
- . Mining & Excavation Equipment
- . Petroleum Production & Refining Equipment
- . Pollution Control Equipment
- . Railway Equipment
- . Security & Safety Equipment
- . Telecommunications
- . Transportation
- . Water Resources

IV. INDUSTRY DEFINITIONS

PHOTOVOLTAIC CELLS convert light into electrical energy. Light shining upon these cells stimulates movement of electrons within the cell; the subsequent voltage creates a current which can be used outside of the cell.

Some photovoltaic products are used in instrumentation and control devices ("electric eyes") for industrial processes, yet most of photovoltaic cells are used to generate electricity for a wide range of applications. This profile deals with the terrestrial (non-space) electricity generation segment of photovoltaic applications.

The term "Photovoltaic Industry" originally referred to the production of the photovoltaic cells and the circuitry necessary to connect the cells to utilize the generated current. However, a new product segment has evolved; the photovoltaic industry has become very involved in the design, production, and marketing of accessory and support products. These additional products expand the list of possible applications for photovoltaic cells, thus enhancing the potential for growth of the whole photovoltaic industry. Typical products for both electrical generation and accessory product lines are defined and described below.

ELECTRICAL GENERATION

Photovoltaic cells are disks or squares of specially treated silicon or other material which, when exposed to light, generate a voltage.

Photovoltaic panels (or modules) contain a number of photovoltaic cells which are encapsulated or sealed between metal and transparent plates; the panels are either flat-plates or use special designs to concentrate sunshine on the cells. The electrical output from the panel (under standard conditions) depends on the efficiency and number of the cells within; presently, individual panels normally produce about 20 to 40 watts of peak power. Modules can also be purchased in 5w peak and 10w peak sizes, however.

A photovoltaic array is a group of photovoltaic panels, all connected together to produce a predetermined voltage for either an energy storage system or for energy-using devices without storage.

Peak watt, a term which refers to the maximum electrical output under standard conditions, (approximately noontime on a clear day); because output is directly dependent upon intensity of sunlight, actual output of a particular system at a particular site will vary with latitude, location, weather and time of day.

POWER CONDITIONING

Inverters change the direct current produced by the cells or stored in batteries to alternating current for use with alternating current appliances and motors.

Charge controllers protect the battery systems from both excessive charge and discharge.

Regulators insure that the voltage from the photovoltaic arrays and battery systems remains within a predetermined range.

ENERGY STORAGE

Batteries

A bank of batteries is one or more batteries which store the energy that is generated by the photovoltaic array. The type and size of the battery system depends upon the requirements of the specific application.

Other Storage

Some photovoltaic systems have inherent self-storing characteristics so that battery storage is either not required at all or only in small amounts. Examples of such systems are water pumping and refrigeration systems where the water and "cold" are stored.

END-USE EQUIPMENT

A range of accessory products are available from photovoltaic manufacturers and other suppliers which are designed to meet the requirements of photovoltaic generating systems.

The following accessories are commonly used in remote villages, home and agricultural electrical power generation systems:

- Fans
- DC Motors
- Pumps
- Refrigerators
- Washing Machines
- Grain mills & food processing equipment
- Audio/Visual Equipment
- Lighting
- Television and Radios
- Communication Equipment

The products are designed to be extremely reliable and highly energy efficient; thus they are appropriate for uses ranging from remote villages to modern vacation homes.

A substantial portion of the photovoltaic market is comprised of products for specialized, remote applications such as:

- Microwave repeater stations
- Corrosion Protection
- Navigational aids, and
- Remote sensing devices.

V. TRENDS & TECHNOLOGICAL DEVELOPMENTS

The photovoltaic industry has matured rapidly over the past decade. A study recently completed * indicates that actual sales of the U.S. Photovoltaic industry in 1979 totaled \$31 million of which \$17 million was domestic sales and \$14 million (45 percent) was export sales. Total U.S. sales of components and systems are expected to exceed 50 million dollars in 1980, increasing to an estimated 150 million dollars by 1982.** Overseas sales are expected to constitute about half of total sales through 1982. New technology and market developments promise immense industry growth during the next few decades; the industry expects to double in size each year through 1982.

Photovoltaic cells were first developed in 1954 and were used for power generation in spacecraft. The great expense of the cells restricted the growth of the photovoltaic market because conventional alternatives were comparatively inexpensive. However, the oil embargo of 1973 caused the photovoltaic industry to become seriously interested in terrestrial applications and commercially oriented products. Since then, photovoltaic technology and market maturity have advanced significantly; the cells are providing reliable power in hundreds of applications around the world. Economic incentives for using photovoltaic systems have also improved drastically; photovoltaic modules that sold for over \$500 per watt of peak power capacity in the mid 1960's are selling in the range of \$10 per peak watt, or less, for large lot purchases, FOB factory U.S.A. (Of course, the price for complete systems varies greatly with the kind of end-use application required.) Thus, today's photovoltaic cells are becoming competitive in an increasing number of markets requiring small and moderate amounts of reliable power in remote areas.

* Baseline Study of U.S. Solar Exports , IIT Research Institute for the Solar Energy Research Institute, October 1980.

** Photovoltaic Industry Study , Solar Energy Industries Association, September 11, 1980.

MARKET TRENDS

The market for photovoltaic (PV) products is growing by 50 to 100 percent per year because of customer acceptance in a variety of applications. This customer acceptance is based upon superior product quality as well as competitive cost in a number of applications.

The superior qualities noted by customers include:

- . Silent operation - no moving parts
- . Reliability - Solid state device
- . Convenience - no refueling; long battery lifetimes; no waste product disposal; and little maintenance is required.

Although installed stand-alone photovoltaic power systems cost from \$10-\$50 per peak watt today, they are cost competitive now where a small amount of power is needed. In these cases, the cost may be about 10 to 100 times less for PV systems than for primary batteries. PV systems can also compete with diesel or gasoline generator life-time costs in sizes up to 10 kw, given the world price of petroleum products.

Even when the loads are in the appropriate ranges for using the diesel generators, maintenance requirements and the cost of fuel delivery can raise the cost of conventional systems above the cost of a PV system. Lowering prices for PV products and increasing prices for diesel will further enhance the economic viability of PV systems. In terms of reliability and convenience, comparisons favor the PV system whenever reasonable amounts of sunshine are available.

Cumulative sales of photovoltaic products through 1976 totalled about 392 KW of peak power. In 1980, however, production should be in the range of 3,000 to 4,000 KW peak power. Most of these sales are commercial, although the U.S. government has purchased one quarter to one third of the industry's production in recent years. Approximately half of the sales are domestic and half are foreign. Recently, telecommunications, cathodic corrosion protection, agriculture, and navigational aids were the major terrestrial applications of photovoltaic cells; communications accounted for over one half of the commercial market. U.S. firms will continue to sell in these segments in the near future, as new market areas develop.

SYSTEMS DEVELOPMENT

A rapidly growing demand in the last two years has induced manufacturers to develop product lines which include reliable, energy efficient accessories to be incorporated in

integrated power generation and end use systems. DC motors for water pumping and village industries, refrigeration for remote medical and recreational facilities, televisions for remote education or recreation, air circulation systems, lighting, and radio and telephone communications have been developed for use with photovoltaics. The recent availability of these products has paralleled the growth of photovoltaic sales for the recreational home market in developed countries. This recent focus on systems development, combined with rapidly decreasing unit cost of the cells, should cause sales of whole systems to amount to a larger share of total sales in the near future.

A significant milestone in residential applications of photovoltaic cells was passed this year when a photovoltaic-powered home began operation in Arizona. Photovoltaic cells will provide essentially all of the power needed by the house; excess power will be transferred to the public utility grid. The project will provide photovoltaic manufacturers, building contractors, and others with vital data which will demonstrate the potential of photovoltaics in the residential housing market. This demonstration should bring domestic residential application of photovoltaic products much closer to reality in the domestic U.S. market as well as selected sites overseas.

FOREIGN TRADE

Foreign markets are essential to the photovoltaic industry. It is currently estimated that nearly half of U.S. production is sold overseas. The strength of foreign markets has encouraged growth of foreign manufacturers; companies in France, Germany and Japan are actively producing products and expanding their international market participation (see Section VI, Competitive Factors). A number of other countries are very active in cell technology research and construction of photovoltaic power generation sites. Notably, plans have recently been announced for the fabrication of systems and some components in African and Latin American countries.

In response to the growing appeal of photovoltaic systems in developing countries, companies are beginning to sponsor manufacturing ventures in foreign countries. Current plans call for importation of cells which will then be assembled into panels and systems. One fabrication plant is planned for the Ivory Coast where the products will initially power a national system of educational television.

FEDERAL SUPPORT

Though the U.S. is still the leader in research and production, increasingly strong foreign competition is

assured. The U.S. Congress is presently evaluating possible support it might provide to help domestic manufacturers retain their market position; this is in addition to related efforts presently pursued by the Department of Energy (DOE). The rising cost of imported fuels is creating an immense financial strain for all nations, especially the developing nations. Consequently, international PV markets should become increasingly important in the next few years especially in the wealthier sectors of developing countries.

The U.S. Government provides funding for research, technology development, and market development. In 1978, two laws were passed to support photovoltaics: one authorized \$98 million over three years for federal purchases of photovoltaic systems, the other allotted \$1.5 billion for research, development, and demonstration over the next decade. This involvement, combined with increasing investment from the private sector, indicates the support that the photovoltaic industry may receive for the next 8 to 10 years.

RESEARCH TRENDS

There are two primary categories of photovoltaic research: basic cell technology and automated production techniques. Presently, primary attention is being given to the techniques of mass production for the type of silicon cells now being produced. The industry is also increasing the research and development of accessory systems which expand the market by creating new applications for today's less expensive cells. Cell technology research however, is still important to the industry; continued market expansion in the future will increase the need for new types of efficient and inexpensive photovoltaic cells.

MASS PRODUCTION TECHNIQUES

A substantial portion of the photovoltaic cell production cost can be traced to the slow cell material growth process and the material waste caused by the need to slice wafers from cylindrical ingots of single crystal silicon material. Government and industry laboratories are performing extensive research on alternate cell production techniques. Recently, promising results have been achieved using a process that creates a "ribbon" of silicon material that can be processed into rectangular photovoltaic cells. Initial results indicate that the rate of silicon material production can be increased dramatically, and material waste reduced substantially using this new process.

Another large portion of the production costs stems from the assembly of the individual cells and modules. Automated

processes which wire and encapsulate the cells have recently come into use. The significant market growth of the past two years has encouraged major capital investments in the new processes by the government and private companies. The resultant boost in production capacity brings the estimated 1980 capacity to more than 5,000kw peak power. (Although actual production may be expected to be in the 3,000 - 4,000kw range). This capacity will increase further in the next two years as new facilities are completed.

Several firms are presently planning building production facilities capable of producing 5,000kw of photovoltaic cells annually. In addition, the first major financial commitment to the photovoltaic industry by public utilities was recently awarded to a major electronics firm. This landmark venture entails the construction of a large-capacity production facility to make silicon "ribbon" cells in very large quantities. These major advancements in technology and production capabilities are hoped to enable the photovoltaic industry to meet the Department of Energy goal of \$.70 per peak watt by 1986.

CELL TECHNOLOGY TRENDS

Improvements of the cell efficiencies have been achieved experimentally; however, since these cells require expensive materials, further work is needed. Additionally, materials such as cadmium sulfide and gallium arsenide are being investigated as alternatives to silicon as the material for photovoltaic cells.

APPLICATIONS AND DEMONSTRATIONS

Working with industry, the Department of Energy has fielded hundreds of photovoltaic systems ranging from a few watts for navigation aids and lights, to a 100 KW general power system at Natural Bridges, Utah. The Federal Photovoltaic Utilization Program alone has funded 3000 photovoltaic systems for use by U.S. federal agencies. The U.S. also has negotiated cooperative agreements to install PV projects in Italy and Saudi Arabia, sharing the costs of the projects with the respective governments.

In summary, the continued growth of the U.S. photovoltaics industry seems assured, regardless of the effect of future external support. The technology has spawned strong, diverse domestic and international markets, and the potential of the new markets has encouraged substantial private investment for further development of the technology.

SCHEMATIC DRAWING OF A PHOTOVOLTAIC POWER SYSTEM

PHOTOVOLTAIC AND DIESEL ENERGY COST COMPARISONS

ASSUMPTIONS

DIESEL

- 20 YEAR LIFE
- \$3/GALLON FIRST YEAR FUEL COST
- 4 KVA DIESEL UNIT
- MFG. APPROVED MAINTENANCE SCHEDULE;
\$10/HR LABOR CHARGE
- 7% REAL FUEL ESCALATION
- 15% DISCOUNT RATE

PHOTOVOLTAICS

- 20 YEAR LIFE
- 1.6KWH ANNUAL ENERGY OUTPUT
PEAK WATT
- 15% DISCOUNT RATE

ENERGY COST,
\$/KWh (1980 DOLLARS)

SOLAR PHOTOVOLTAIC ELECTRIC FENCER

PARKER McCORMY MANUFACTURING CO.

PHOTOVOLTAIC-POWERED COMMUNICATIONS RELAY STATION

MOTOROLA COMMUNICATIONS & ELECTRONICS, INC.

PHOTOVOLTAIC VILLAGE POWER PROJECT - SCHUCHULI, ARIZONA

VI. COMPETITIVE FACTORS

European Competition *

Today U.S. manufacturers dominate the world market with European production representing about 18 percent of the world total for 1979. Only Phillips is currently a major competitor although Telefunken and Japanese firms could be major competitors in the next few years. The European presence in the world photovoltaics market is closely linked with overseas development assistance funding. French development assistance is largely responsible for the attention West Africa is receiving today as a major potential market. German exposure overseas is almost exclusively related to government development activities in support of PV demonstrations. The current focus of European firms and U.S. exporters on the Francophone African markets reflects early French attention in this area. Europeans view the major PV markets to be in developing countries and other regions where central station grid-power is not available.

European firms currently active in photovoltaics include: AEG Telefunken, Wacker-Chemie GmbH, Philips, La Radiotechnique-Competec, France-Photon and Photowatt International. The European PV industry is comprised of a few large multinational corporations, most of which are active in electrical and electronic equipment and telecommunications equipment. A few are major firms with impressive capabilities in silicon materials. All support internal R & D programs.

Some U.S. companies have established links with European firms, particularly with French corporations. Joint ventures with U.S. PV manufacturers provide European firms with advanced PV manufacturing capabilities, a proven PV product, and access to U.S. R&D results. In turn, U.S. manufacturers benefit from capitalization, improved market position, and access to European R&D.

*The following sections are adapted from Characterization and Assessment of Potential European and Japanese Competition in Photovoltaics, Science Applications, Inc., for the Solar Energy Research Institute, October 1979 (SERI/TR-3251-1)

Throughout Europe a large number of universities, research institutions, and industrial research centers are performing R&D work related to photovoltaic systems. The total government funds available for this R&D are in excess of \$35 million annually; France and Germany providing more than 85 percent of the total. U.S. R&D today is in a lead position in most areas of European R&D activity. The notable exception is the cast ingot polycrystalline effort in Germany.

If a cell technology "breakthrough" occurs at a European research center, the U.S. is in a position to develop that technology rapidly. If the reverse happens, at least one European country will be able to develop the technology quickly. This reflects the focused programs of European programs in comparison to the broader U.S. programs.

Japanese Competition

Since World War II Japan's industry has developed several groups of strong manufacturing firms--each with activities in the electrical, electronics, and semiconductor areas. Soon after the photovoltaic cell was invented at AT&T's Bell Labs in the mid-1950's, Japanese firms began to manufacture cells on a pilot basis. While devoting major resources to transistor and later integrated circuit production, each major group company has maintained activity in photovoltaic cell research, development, and manufacturing.

There are about ten companies in Japan which are actively involved in photovoltaic production, or which have the potential, based upon similar product lines, to enter the field quickly. These ten companies are Fujitsu, JSEC (Japan Solar Energy Company), Hitachi, Matsushita (U.S. trade name Panasonic), Mitsubishi Electric Industrial Company, NEC (Nippon Electric Company), Sharp, Sony, Toshiba, and Toyo Silicon. These firms are very large, having annual total sales in the range of 1 to 10 billion dollars. Semiconductor sales and, in particular, photovoltaic sales comprised a small fraction of the total sales. This situation appears to be typical of most Japanese PV manufacturers. Extensive exporting of numerous products has allowed the seven major companies combined to establish affiliate companies in 22 countries, subsidiary companies in 9 countries, and branch offices in 51 countries. The sales and distribution networks of these companies are prepared for increased marketing and export of photovoltaic devices.

Total Japanese sales are estimated to range between 30 and 50 KWp in 1978 and maximum Japanese production in 1979 was estimated between 40 and 80 KWp. Two general

observations can be made: domestic sales are small and depend mainly on government purchases. Secondly, foreign sales are limited and the module prices are high. The Japanese domestic market is not impressive. It is expected to develop slowly and perhaps reach 200-400 KWp annual sales in 1985. A small potential market exists because the country has a highly developed central utility grid and few undeveloped regions.

In the area of foreign sales, Japanese export activities can be summed up as exploratory. Japan exports PV systems to a wide range of countries in Africa, South America, and Asia. Australia is considered a leading market area. Most U.S. PV companies state that they rarely compete with Japanese products. A partial reason for this is that the world PV market is extremely fragmented today; characterized by small volume sales over broad geographical regions. It is not uncommon to meet few competitors except where the potential sales are of significant size and frequency.

"Project Sunshine," the broad Japanese government R&D program in solar energy, includes work on photovoltaics; the program emphasis is on cell fabrication techniques, especially those related to mass production.

The Japanese R&D effort in photovoltaics reflects an interest to keep up with worldwide technological developments, but little emphasis is placed on market stimulation or systems development specifically for photovoltaics. This posture will allow Japanese industry to exploit breakthroughs or technological developments made in photovoltaics, while minimizing the risk involved.

VII. PERTINENT ECONOMIC INDICATORS

Since photovoltaic power systems are being used in a wide variety of economic and industry sectors, it is difficult to provide reliable economic indicators of market potential. However, a number of trends may indicate significant demand for selected photovoltaic products; these are listed below (with appropriate PV applications):

- Sales of remote thermal power generation devices
- Sales of primary and storage batteries (photovoltaic battery chargers)
- Sales of recreational equipment and housing (power for recreational cabins; battery chargers for small boats)
- Sales of small diesel and gasoline electricity generators; cost of fuels
- Plans for expansion of rural medical programs (medicine refrigeration and communications)

- Limits to extension of rural power grid (demand for stand-alone systems)
- Growth of ship and rail transportation systems (navigational aids; signal and caboose power)
- Demand for micro-irrigation systems
- Development of educational television and radio systems
- Development of cottage industry, agricultural and other development programs where small power generation equipment may be required
- Sales of electrical consumer goods in remote, off-grid areas
- Construction of bridges and pipelines (corrosion protection)

VIII. CHANNELS OF DISTRIBUTION

Distinct distribution channels for photovoltaic systems have not been established. However, it is expected that they will generally follow usual distribution routes and will vary with the type of photovoltaic system involved. Many systems are now being sold using the following conventional channels:

- Manufacturer direct to end-user
- Manufacturer to end-use component supplier (e.g., pump, refrigerator, etc.) to end-user
- Manufacturer (to wholesaler) to retailer to end-user (e.g., small packaged systems such as battery chargers)
- Manufacturer to contractor to end-user
- Manufacturer to distributor (wholesaler or system house) to end user/retailer/end use component supplier

IX. INDUSTRY-ORGANIZED TRADE PROMOTION EVENTS

The following list of trade shows and exhibitions includes functions which specifically address photovoltaic and other solar systems as well as functions which serve related industries where photovoltaic systems are beginning to establish a significant role; i.e., building products, power generation, telecommunications, and others. While this listing is not intended to be comprehensive, especially with regard to related industries, it is intended to include the major solar shows along with examples of major related industry shows. Some shows are scheduled to repeat every year or every other year. Purely technical or professional meetings have not been listed.

1980

Nov. 19-14 Arabbuild 80 - the Middle East Building and Construction Industry

Location: Exhibition Centre, Bahrain

Contact: Dobson, Gerry
Arabian Exhibition Management
11 Manchester Square
London W1M 5AB
England
Tel:01-486-1951

Comments: Incorporates Soltech 80 - 2nd Middle East Solar Technology Exhibition.

Nov. 19-22 ENERGIA

Location: Hamburg, West Germany

Contact: Stammers, Judith R.
Executive Director
Solar Trade Association, Ltd.
26 Store St.
London WC1E 7BT
England
Tel:01-636-4717

Comments: International exhibition of solar technology and alternative energy.

Dec. 2-5 Energi 80

Location: Copenhagen, Denmark

Contact: Boersens Exhibition Service
Moentergrade 19
DK-1014 Copenhagen
Denmark
Tel:45-1-15 72 50

Comments: Contact between all facets of the international energy community including product displays, conferences, field trips, etc.

1981

Jan 15-21 Jedda 81 - The 4th Middle East Construction
Exposition

Location: Jedda, Saudi Arabia

Contact: Mason, Wm. J.
Director, Int. Sales
Cahners Exposition Group
331 Madison Ave.
New York, NY 10017
Tel:(212)682-4302

Feb 1-5 Solar Energy Utilization in Developing Countries

Location: University of Baghdad, Baghdad, Iraq

Contact: Tappune, Riadh
University of Technology
Baghdad Solar Energy Symposium
P.O. Box 745
Baghdad
Iraq

Comments: Use of solar energy in buildings, in farming, and
for desalinization in developing countries,
especially in Arabic countries.

Feb. 2-5 MECOM 81

Location: BAHRAIN

Contact: Jeff-Wolf
TMAC
680 Beach Street Suite 428
San Francisco, CA. 94109
(800) 227-3477
(415) 474-3000

Comments: Communications Show and Conference will attract
planning and procurement officers, engineers
and government officials from the National
Telecommunications Authorities, defense services
and private companies of the Middle East.

Feb. 28 -

Mar 5 The Middle East Electricity Exhibition 1981

Location: Jeddah Expo Centre, Jeddah, Saudi Arabia

Contact: Mason, William J.
Director Int'l Sales
Cahners Exposition Group
331 Madison Ave.
New York, NY 10017
Tel:(212)682-4302

April 6-11 INOVA 81

Location: Paris, France

Contact: Jeff Wolf

TMAC

680 Beach Street

Suite 428

San Francisco, CA 94109

(800) 227-3477

(415) 474-3000

Comments: Exhibit and conference topics include technology transfer, renewable energy sources, and more. INOVA 81 will draw top executives, engineers and technicians to view and exchange the latest developments in the world high technology marketplace.

Aug 23-29 International Solar Energy Society Congress and Exhibition

Location: Congress Centre, Brighton, England

Contact: Morton, June

19 Albemarle St.

London W1K 3HA, England

Tel:01-493-6601

Sponsor: International Solar Energy Society/United Kingdom Section

Comments: Covers various solar fields with emphasis on technological and training support for developing countries. Held with large exhibition on renewable energy and energy conservation.

Sep 8-12 INELTEC 81

Location: Basel, Switzerland

Contact: Sekretariat INELTEC

Swiss Industries Fair Basel

CH-4021 Basel

Switzerland

Dec 9-12 COMMUNACASIA 21

Location: Singapore

Contact: Jeff Wolf

TMAC

680 Beach Street Suite 428

San Francisco, CA 94109

(800) 227-3477

(415) 474-3000

Comments: 2nd Asian International Electronic Communications Show & Conference. Key decision makers and buyers from over 21 Asian countries to be present.

1982

CONSTRUCTION INDONESIA	Jakarta INDONESIA	Mar 2/5, 1982
EDUCATION ARABIA 82	BAHRAIN	Mar 21/25, 1982
MIDDLE EAST BUSINESS EQUIPMENT SHOW	BAHRAIN	Mar 21/25, 1982
HOSPITAL INDONESIA	Jakarta, INDONESIA	Mar 30 -Apr 3, 1982
TECHNOLOGY RESOURCES EXCHANGE FAIR	Sydney, Australia	May, 1982
EDUCATION INDONESIA	Jakarta INDONESIA	Sep 21/25, 1982
BUSINESS INDONESIA	Jakarta INDONESIA	Sep 21/25, 1982
ARABBUILD 82/SOLTECH 82	BAHRAIN	Nov 14/19, 1982
ENGINEERING INDONESIA	Jakarta INDONESIA	Nov 16/20, 1982

1983

ELECTRIC INDONESIA	Jakarta INDONESIA	Mar 8/12, 1983
FORESTRY/AGRICULTURE INDONESIA	Jakarta INDONESIA	Nov 8/12, 1983

X. U.S. GOVERNMENT ORGANIZED TRADE PROMOTION EVENTS

A variety of trade shows, exhibitions and commercially-oriented seminars are scheduled or are currently being developed which should provide substantial exposure for photovoltaic systems. Although the trade shows sponsored by the Department of Commerce (DOC) are generally targeted to conventional industries (e.g., agriculture, medical equipment etc.), they provide ample opportunity to display selected photovoltaic powered applications (e.g., micro-irrigation, medical refrigerators, etc). A list of industry shows and applications is provided on Chart X-1, "Available Photovoltaic Products and Applications Relevant for Selected Industries." In addition to these DOC shows, a series of seminars and exhibitions have been arranged specifically for solar products developed jointly by DOC and DOE. And finally, special U.S. Solar industry components are being arranged for a number of shows sponsored by organizations other than DOC/DOE. A listing of all DOC/DOE target solar events for FY81 is provided below.

The contact for the DOC/DOE-sponsored events is:

Solar Trade Events
Attn: Michael T. Panich
HRM, Inc.
1101 30th Street, N.W. Suite 301
Washington, D.C. 20007
Telephone: (202) 338-9071
Telex: 248686 HRMUR

This contact should also be used for events listed here (although sponsored by organizations other than DOC/DOE) in order to ensure coordination of U.S. industry participation.

DOC/DOE - Sponsored Trade Events (Tentative List, October 1980)

February, 11-25, 1981	Solar Energy - U.S.A.
Location:	Madrid-Zurich, Rome, Athens
Sponsor:	DOE/DOC
Comments:	Exhibitions in Madrid and Athens; Zurich & Rome to include seminar only.
March 14-28, 1981.	Cairo International Fair
Location:	Cairo, Egypt
Sponsor:	DOC/DOE
Comments:	Includes seminar & exhibition of solar products.

April 28-30, 1981

Location:

Sponsor:

Comments:

Mexico City Seminar &
Exhibition

Mexico City, Mexico

DOE/DOC

Includes seminar & exhibition
of solar products.

April 29 - May 4, 1981

Location:

Sponsor:

Comment:

Tech Ex '81 - World Conference

Columbo, Sri Lanka

Sri Lanka

Product exhibition only.

May 13 - June 3, 1981

Location:

Sponsor:

Comments:

Far East Energy Event

Jakarta, Manila, Tokyo, Seoul

DOE/DOC

Seminars only at all four
locations.

August 23-28, 1981

Location:

Sponsor:

Comment:

World Congress & Exhibition,
International Solar Energy
Congress Centre

Brighton, England

ISES, United Kingdom Section

Technical conference with
associated solar product
exhibition.

September 11-20, 1981

Location:

Sponsor:

Comment:

Zagreb Exhibition & Seminar

Zagreb, Yugoslavia

Yugoslavia

To include exhibition &
seminar

September 11-30, 1981

Location:

Sponsor:

Comments:

South American Energy Event

Buenos Aires, Sao Paulo

DOE/DOC

To include exhibitions &
seminars.

XI. TRADE ASSOCIATIONS AND TRADE JOURNALS

A. Trade Associations

1. Solar Energy Industries Association
Mr. Raymond Kendall, Chairman
Photovoltaics Division, SEIA
Motorola, Inc.
8201 East McDowell Road
Scottsdale, AZ 85257
(602) 949-3775

Solar Energy Industries Association
1001 Connecticut Avenue, N.W.
Suite 800
Washington, D.C. 20036
(202) 293-2981
Attn: Mr. George Tenet, Vice Chairman
International Trade Committee

2. International Solar Energy Society
American Section of the International Solar Energy Society
American Technological University
P.O. Box 1416
Killeen, TX 76541
(317) 526-1300
Attn: Mr. G. Lee Salmon, Executive Director

B. Trade Journals

1. Solar Engineering Magazine
Anna Fay Friedlander, Executive Editor
Published monthly by Solar Engineering Publishers, Inc.
Editorial Offices: 8435 North Stemmons Freeway,
Suite 880 Dallas, TX 75247
(214) 630-6963
Circulation Offices: GPO Box 1736
Brooklyn, NY 11202
(212) 834-0550
Annual subscription (13 issues) : USA \$20
International \$29
2. Solar Age
(The official magazine of the American Section of the International Solar Energy Society)
Published monthly by Solar Vison, Inc., Church Hill,
Harrisville, NH 03450, (603) 827-3347
Bruce Anderson, Executive Editor
Subscription offices: P.O. Box 4934
Manchester, NH 03106
Annual subscription: USA and Canada \$20
Other countries \$32

3. Solar Heating and Cooling
 Laura Benson MacKenzie, Managing Editor
 Published monthly by Gordon Publications, Inc.
 20 Community Place, Morristown, NJ 07060
 Annual subscription: USA \$15

4. Solar Energy Intelligence Report
 Allan L. Frank, Editor
 Published weekly by Business Publishers, Inc.,
 P.O. Box 1067, Silver Spring, MD 20910,
 (301) 587-6300
 Annual subscription: USA, Canada and Mexico \$127
 Other countries \$152

5. World Solar Markets
 Mark Newham, Editor
 Published monthly by the Financial Times,
 Business Information Limited, Registered Office,
 Bracken House, 10 Cannon Street, London EC4P 4BY,
 Telephone 01-248-8000, Telex 8954871
 Representatives in the USA,
 FT Publications, Inc.
 75 Rockefeller Plaza
 New York, NY 10019
 Telephone (212) 489-8300
 Telex 23423025
 Annual Subscription: USA \$350

6. Canadian Renewable Energy News
 Douglas Nixon, Editor
 Published monthly by CREW Publishing, Ltd.
 P.O. Box 4869, Station E
 Ottawa, Canada K1S 5B4
 (613) 238-5591
 Single copy price \$.95

7. Solar News International
 Editorial Staff: Kurt Wentwig, Karlsruhe
 Pierre Benichon, Paris
 Published twice monthly by the ICP Group in English,
 French and German

West Germany	FranceFrance
Promotor Verlags-und	PYC-Edition
Forderungsges. mbH.,	Yves Colombot
Hardtstrasse 26,	254, Rue de Vaugirard
D-7500 Karlsruhe 21	F-75740 Paris Cedex 15

Subscription rates: DM 240
 FF 520

C. Solar Product Catalogs

1. SEM 80: Second Annual Solar Product Listing
Incorporated in Solar Engineering Magazine,
Mid-April 1980
Circulation offices: GPO Box 1735
Brooklyn, NY 11202
(212) 834-0550
Editorial Offices: 8435 North Stemmons Freeway,
Suite 830, Dallas, TX 75247
(214) 630-6963
Individual copy price (232 pp.) \$10 (\$14 outside
the U.S.)
2. Solar Energy Source Book, Second Edition (1979)
Solar Energy Institute of America
1110 Sixth Street, N.W.
Washington, D.C. 20001
(202) 667-6611
Copy price (797 pp.): \$15

XII. PHOTOVOLTAICS PRODUCT MANUFACTURER'S LIST

Supplied by
Solar Energy Industries Association (SEIA)

The following list represents the best efforts of the SEIA to compile a list of U.S. photovoltaic manufacturers of systems, cells, modules, concentrated cells, system component manufacturers, sun trackers and control testing laboratories.

The list is not restricted to members of SEIA. SEIA does not endorse the products of any of the companies listed. Any omission from the list have been unintentional and SEIA should not be held responsible.

For further information relating to photovoltaic programs of SEIA please contact:

Mr. George Tenet
Director of Photovoltaic &
International Programs
Solar Energy Industries Association (SEIA)
1001 Connecticut Ave. N.W. Suite 800
Washington, D.C. 20036
Phone: (202) 293-2061

XII. PHOTOVOLTAICS PRODUCT MANUFACTURER'S LIST (SEIA)

<u>Systems</u>	<u>System Component Manufacturer- Storage-Power Conditioning & Controls</u>
Acurex Corporation	<u>Batteries</u>
Arco Solar, Inc.	
BDM Corporation	C&D Batteries
E-Systems	Delco
General Electric	Exide Corporation
Martin-Marietta	
Motorola	<u>Inverters</u>
Photowatt International	
Solar Power Corporation	AiResearch
Solarex Corporation	Abacus
United Energy Corporation	East
	Delta
	Ecotronics
	Exide
	Power Systems & Control
<u>PV Cell/Module</u>	Teledyne Inet
<u>Manufacturer</u>	U.T.C. (United Technologies)
Applied Solar Energy Corp	Westinghouse
Arco Solar Inc.	Windworks (Gemini)
Motorola, Inc.	
Photon Power	
Photowatt International	<u>Sun Trackers</u>
SES, Inc.	
Solar Power Corporation	Acurex
Solarex Corporation	General Electric
Solec International	Motorola
Solenergy Corporation	
Spire	
United Energy Corporation	
<u>Concentrator Cells</u>	<u>Control Testing Laboratories</u>
Applied Solar Energy Corp.	DSET
Microwave Associates	Wyle Laboratories
Motorola	
Solarex	

*For complete mailing address/telephone details see following pages.

Abacus Controls, Inc.
P.O. Box 893
Somerville, N J 08876
George A. O'Sullivan
(201) 526-6010

Helionetics
Delta Electronic Control Div.
17312 Eastman St.
Irvine, California 92714
Dick Seaman
(714) 546-4731

AiResearch
Manufacturing Co. of CA
Electric Power Systems
Sales Group
2525 West 190th St.
Torrance, California 90509
J.W. Main
(213) 323-9500 Ext. 2191

Martin Marietta Manufacturing
Box 179 Mail Sta. CO 470
Denver, Colorado 80201
John Sanders
(303) 977-0510

Acurex
485 Clyde Avenue
Mountain View, CA 94040
Gary Heuner
(415) 964-3200

Motorola
8201 East McDowell Ave
Scottsdale, AZ 85257
Raymond Kendall
(602) 949-3775

Applied Solar Energy Corp.
15251 E. Don Julian Road
City of Industry, CA 92632
Robert Brown
(213) 968-6581

Power Systems & Control
1730 Kelley Road
P O Box 27306
Richmond, Virginia 23261
Charles Gregory
(804) 355-2802

Arco Solar
20554 Plummer Street
Chatsworth, CA 91311
George McClure
(213) 998-2482

Photon Power, Inc.
10787 Gateway West
El Paso, TX 79935
Martin Wenzler
(915) 593-2861

Best Energy Systems
Route 1, P.O. Box 106
Mecedah, WI 54646
Steve Paul
(608) 565-7200

Photowatt International, Inc.
2414 W. 14th Street
Tempe, AZ 85281
Robert McGinnis
(602) 394-9564

BDM Corporation
2600 Yale SE
Albuquerque, NM 87106
George Rhodes
(505) 848-5309

SES, Inc.
Tralee Industrial Park
Newark, DE 19711
Robert Johnson
(302) 731-0990

C & D Batteries
3043 Walton Road
Plymouth Meeting, PA 19462
Darwin Delans
(215) 828-9000

Solar Power Corporation
20 Cabot Road
Woburn, Mass 01801
Jim Skane
(617) 935-1101

Delco Remy
2401 Columbus Avenue
Anderson, Indiana 4601162
Elmer Reese
(317) 644-5581

Solarex
1335 Piccard Drive
Rockville, MD 20850
Ted Blumenstock
(301) 948-0202

DSET
Box 1815 Black Canyon Stage
Phoenix, Arizona 85209
Gene Zerlaut
(602) 465-7356

Solec International, Inc.
12533 Chadron Avenue
Hawthorne, CA 90250
Ishaq M. Shahryar
(213) 970-0065

E-Systems
1200 South Jupiter
Garland, TX 75222
Dr. Walter J. Hesse
(214) 272-0515

Solenergy Corporation
23 North Avenue
Wakefield, MA 01880
Robert Willis
(617) 246-1855

Ecotronics
(Talley Industries)
7745 East Redfield Rd
Scottsdale, AZ
(602) 948-9003

Spire Corporation Marketing
Patriots Park
Bedford, MA 01730
Wilbur Thomas
(617) 275-6000

Energy Conversion Device
1675 West Maple Road
Troy, Michigan 48084
Mr. Ovshinsky
(313) 280-1900

United Energy Corporation
666 Mapuna Puna Street
Honolulu, Hawaii 96819
Ernest Lampert
(808) 836-1593

Exide
101 Gibraltar Road
Horsham, PA 19044
Gene Cook
(215) 674-9500

Teledyne Inet
2750 West Lomita Blvd
Torrance, CA 90509
Jim Weatherman
(213) 325-5040

General Electric
P.O. Box 8661, Room 114
Philadelphia, PA 19101
Jim Marler
(215) 962-5853

United Technologies Lab.
Governor's Highway
South Windsor, CT 06074
Fred Kornbrust
(204) 727-2322

Westinghouse
P.O. 10864
Pittsburg, PA 15236
D.R. Roberts
(412) 892-5600 Ext. 5342

Windworks (Gemini)
Box 44A, Route 3
Mukawongo, WI 53149
Hans Meyer
(414) 363-4083

Wyle Laboratories
7800 Governor's Drive
Huntsville, AL 35807
Jim Dodd
(205) 837-4411