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Photovoltaic Industry Progress From 1980 to Mid 1986

R. L. Watts
S. A. Smith

August 1986

Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

Pacific Northwest Laboratory
Operated for the U.S. Department of Energy
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PHOTOVOLTAIC INDUSTRY PROCESS FROM 1980 to MID 1986

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Richland, Washington 99352

SUMMARY

World shipments of photovoltaic (PV) modules/cells for all end-uses remained relatively constant for 1983, 1984, and 1985 despite the decrease in government purchases and sales subsidized by various government programs. This indicates a continued strengthening of the commercial markets: a healthy trend. Japanese producers led in total PV shipments in 1985 as a market dominated by Japan-consumer electronics continued to expand in the adoption of PV. The United States led the world in the production of power modules.

The decrease in government-subsidized sales/purchases were nearly equaled by increases in shipments of modules using crystalline silicon cells in stand-alone applications and of amorphous silicon thin film technology in consumer goods and specialty applications. Both sectors are expected to increase shipments again in 1986.

Shipments of PV systems using concentrator technology have fallen sharply due to the cessation by a U.S. company from sale of investment packages based on tax reduction benefits. Two companies are agressively marketing concentrator technology at prices considerably below flat plate in terms of $/watt.

PV sales to the space market represent a market of 100 kilowatts per year not covered in this report.

Prices paid by distributors for PV modules using crystalline technologies have dropped from about $7/watt (w) in 1984 to $5.25 to $5.50/w in 1986. This decrease in module prices is primarily due to increased competition and has not been matched by comparable reductions in production cost. Consequently, profitability has been adversely affected making survival more difficult for smaller firms. Industry revenue declined in 1985 due to the reduction in price and a slight decline in total production volume.

The present price structure appears to have resulted from serious attempts by Japanese and European suppliers to penetrate the U.S. market. Both Japanese and European suppliers have decided that the crystalline silicon module market is worth additional investment in market share. Commercial factors seem more important in current pricing than technological progress; however, efficiencies

continue to increase and production costs to decrease.

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1.0 INTRODUCTION

The growth of the U.S. photovoltaics (PV) industry from 1980 to 1985 has been impressive. In that period the industry dramatically improved the quality of the products offered for sale while reducing manufacturing costs. Initially designed to provide power for satellites using high-cost processes, PV is now the economical choice for supplying electrical power in many remote terrestrial applications. The remarkable growth of PV in the quality of cells and modules, production techniques, and system design, was led by a cooperative effort of the U.S. government and domestic PV manufacturers.

European and Japanese firms entered the PV industry later than the United States, but are also growing rapidly. The European firms supply PV systems for village electrification and water pumping to many Third World countries, in addition to supplying traditional markets such as communications equipment, corrosion protection, and residences. The Japanese industry followed an approach totally different from U.S. and European manufacturers, concentrating on very small cells used to power calculators, watches, and other consumer products. These small cells add up to an area equivalent to many acres of PV power modules. The experience gained in small manufacture certainly adds to the technology base available to the Japanese for an assault on the power module market. In the consumer goods market amorphous silicon (a-Si) thin film technology has largely replaced the single crystal silicon (CZ) cells, since a-Si thin film uses less capital, material, and labor. There is a serious attempt to develop a-Si power modules with the efficiency, reliability, and life necessary to compete with the crystalline PV technologies.

The objective of this report is to describe PV industry developments in 1985 and present forecasts for 1986. Information is presented on a regional basis (United States, Europe, Japan, other) to avoid disclosing company confidential data. Information was gleaned from several sources, including a review of technical literature and direct contacts with many PV manufacturers. Prior to publishing the regional totals, all numbers were compared with those from other sources published in the United States and those supplied by Japanese industry through their solar energy organization.

The information in this report is prepared for use by the U.S. Department of Energy (DOE) in long-range planning activities. However, this information should also be of interest to PV manufacturers and those who may be contemplating entry into the PV market.

This report is divided into four chapters. Chapter 2.0 summarizes PV shipments for 1985 and includes estimates for 1986 shipments based on midyear information. Chapter 3.0 presents technology trends and Chapter 4.0 presents trends in the market sectors receiving PV shipments. Appendix A lists a number of the major events of 1985 through the first half of 1986 as reported in trade publications.

2.0 WORLD PHOTOVOLTAICS INDUSTRY

A preliminary survey suggests that the world photovoltaics industry is expected to grow in 1986, with shipments of cells and modules increasing from 20.5 megawatts (MW) in 1985 to 25 MW, based on mid-year estimates (Figure 2.1). Total world PV shipments remained relatively flat during 1983, 1984, and 1985. Superficially, the market seems to have stagnated during this three year period. Within total shipments, however, large shifts have occurred in 1) the regions producing the PV, 2) the technologies being produced and 3) the market sectors receiving those shipments. The following chapters outline these shifts in more detail.

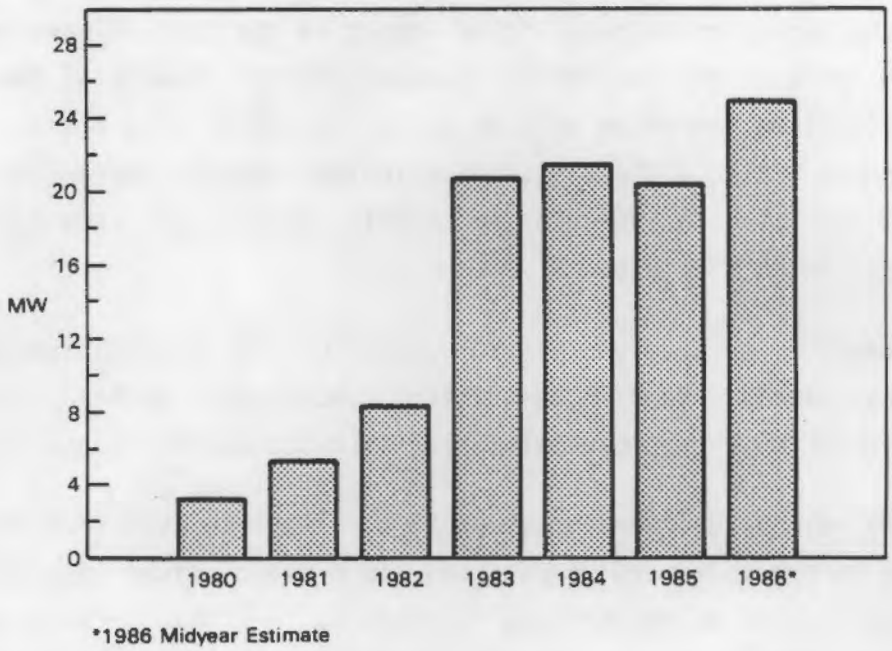


FIGURE 2.1. World PV Shipments

Japan moved ahead of the United States, for the first time in 1985, in total PV production with 8.1 MW compared to the U.S. total of 7.6 MW (Table 2.1). Japan's lead is mainly due to their nearly complete dominance of the consumer PV market; whereas, the United States clearly leads in production of power modules. Europe remained fairly constant with shipments in the range of 3 to 4 MW during 1983, 1984, and 1985. The total for 1986 based on a midyear estimate is expected to remain within that range.

Table 2.1. World PV Shipments (MW)

Region	1980	1981	1982	1983	1984	1985	1986*
US Flat Plate	2.5	2.6	4.3	8.1	8.4	7.6	8.6
US Concentrator	<.1	0.9	0.9**	4.6**	3.1**	0.1	0.1
Total US	2.5	3.5	5.2	12.7	11.5	7.7	8.7
Japan	0.5	1.1	1.7	4.3	6.2	8.1	11.4
Europe	0.3.	0.8	1.4	3.3	3.3	3.5	3.7
Other	0.0	0.0	0.1	0.5	0.6	1.2	1.2
Total	3.3	5.4	8.4	20.8	21.6	20.5	25.0

* Based on 1986 mid-year estimates.
** These figures contain substantial quantities of "tax shelter" shipments.

Thin film technologies made little impact in the form of power module shipments in spite of the continuing concentration of commercial research and development (R&D) on amorphous silicon (a-Si) and other thin films. Concentrator production virtually stopped in 1985 despite impressive technical achievements resulting in increases in overall efficiency. This is discussed in more detail in Chapter 3.0.

The commercial marketplace picked up most of the slack caused by the loss of approximately 3 MW of "tax-shelter" concentrator business in 1985 (Table 2.1). The growth of the commercial market is discussed in Chapter 4.0.

Industry revenue declined to about $360 million in 1985 from $400 million in 1984, due to the increased competition and reduced volume (Figure 2.2). These revenue figures do not include investments in PV R&D or in production equipment, although balance of systems equipment is included. The price of power modules to distributors in large quantities decreased from about $7/Wp in 1984 to $5.25 to $5.50/Wp by mid-1986 (measured in current dollars). Traditional commercial markets continue to show substantial growth, but require considerable investment in customer education and market development for each increment of new business. New technologies that promise large reductions in power module production costs are still being produced in such small quantities that modules made the new way may cost more than the CZ and semi-crystalline modules that they replace. In addition, modules made using new production

techniques have the disadvantage of a less certain life and stability characteristics.

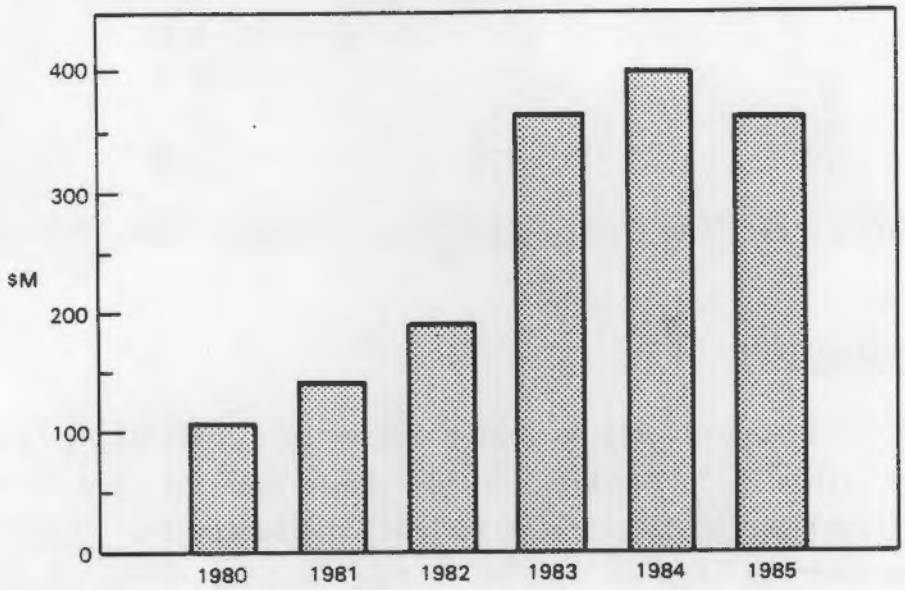


FIGURE 2.2. Total PV Revenue

Other estimates of world PV shipments are available from several sources. Estimates of world PV shipments for 1983, 1984 and 1985 published by Strategies Unlimited are included in Table 2.2. Estimates by Photovoltaic Energy Systems Inc. for 1983, 1984, and 1985 are included in Table 2.3. Differences in these estimates primarily relate to the difference in accounting for the output of augmented modules and in estimating the output of modules used in consumer goods. The regional trends of the PV industry are discussed in the sections immediately following.

Table 2.2. Summary of World PV Shipments According to Strategies Unlimited (MW)

Region	1983 Shipments	1984 Shipments	1985 Shipments
US	9.3	8.5	7.5
Japan	3.8	6.6	6.4
Europe	2.2	2.6	3.7
Other	0.3	0.8	1.8
Total	15.6	18.5	19.4

Source: (1) Best, D. 1985. "Profiling 1984's World Market". Solar Age, April, 1985 pp. 22-23.
(2) Johnson, D. 1986, ...

Table 2.3 Summary of World PV Shipments According to Photovoltaic Energy Systems Inc. (MW)

Region	1983 Shipments	1984 Shipments	1985 Shipments
US	13.1	11.7	8.5
Japan	5.0	8.9	10.8
Europe	3.3	3.6	3.7
Other	0.3	0.8	1.4
Total	21.7	25.0	24.4

Source: Maycock, P. 1986. Photovoltaic News, February, 1986, Vol. 5, No. 2, p. 2.

2.1 U.S. PV INDUSTRY

The United States clearly dominated the world commercial PV industry from 1980 to 1984 (Table 2.1). However, in 1985 Japan took the lead in overall shipments if consumer goods uses are included in the totals. The United States led in the production of power modules in 1985 (midyear estimate) (Figure 2.3) and is expected to continue to lead in power module production in 1986 (mid year estimate).

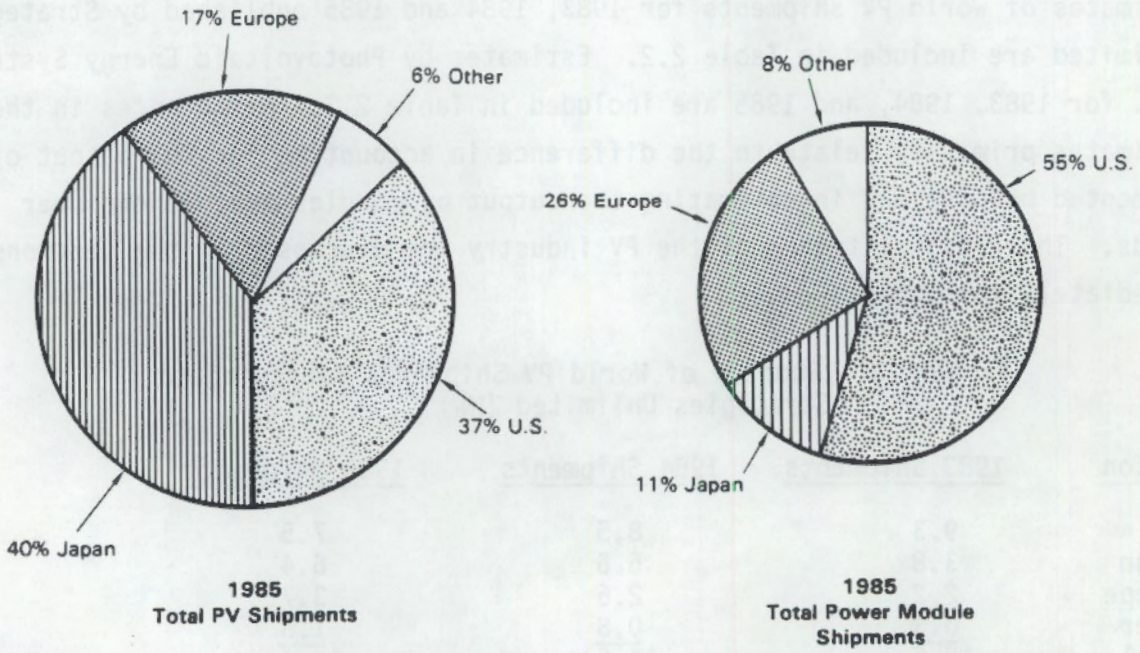


FIGURE 2.3. Regional Market Share for Total vs. Power Module Markets

Total U.S. shipments declined nearly 3 MW from the 1984 total of 11.5 to 7.7 MW in 1985 (Figure 2.4). This decline was primarily caused by the loss in tax-supported concentrator sales. Although U.S. shipments declined from 1984 to 1985, the United States continues to lead in PV power module technology, and was the first to introduce a-Si modules to the commercial power module market. The U.S. commercial market is dominated by two companies, ARCO Solar, and Solarex. ARCO Solar continued to be the world leader in PV manufacturing in 1985 serving a variety of commercial markets. ARCO Solar continued modest shipments of power modules to central station applications, but made impressive gains in commercial market sales. These gains largely offset losses in tax subsidies and direct government purchases. Solarex made similar adjustments to the changed market environment.

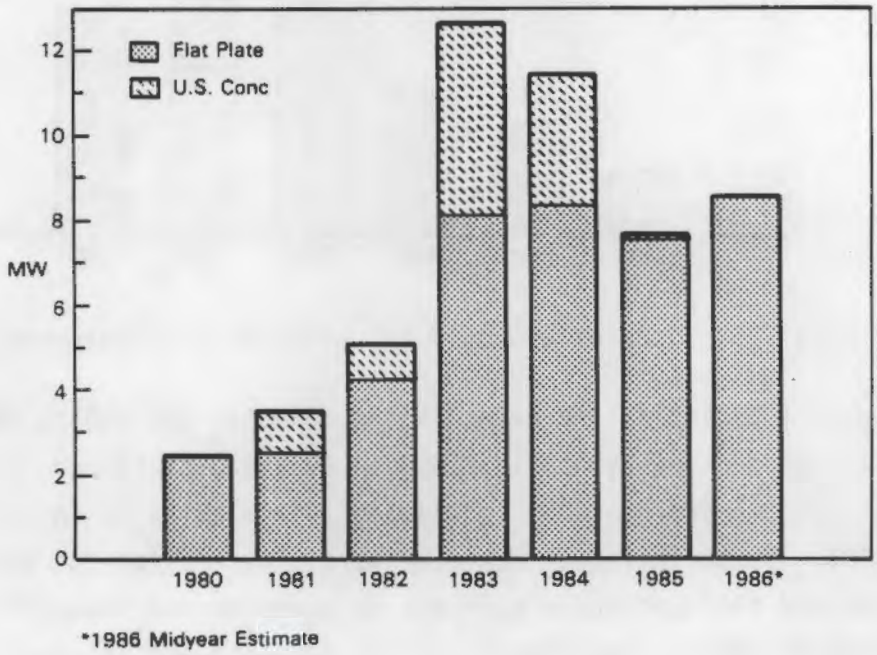


FIGURE 2.4. U.S. PV Shipments

The United Energy Corporation third-party sales of concentrator technology in 1983 and 1984, ended in December of 1984. This loss of concentrator sales is responsible for most of the decline in U.S. shipments between 1984 and 1985. Some of the decline can be traced to a reduction in government purchases and tax incentives on the rest of the flat plate market.

During 1983 and 1984 the U.S. market was stimulated by a combination of direct government purchases and those heavily dependent on financial incentives (Figure 2.5). These shipments amounted to an estimated 8.5 MW in 1983 (70% of U.S. shipments). This MW estimate is conservative because it excludes residential systems whose purchase may have been dependent on the tax incentives. In 1984, federally subsidized shipments had decreased to about 5.5 MW and in 1985 they had further decreased to about 1.5 MW.

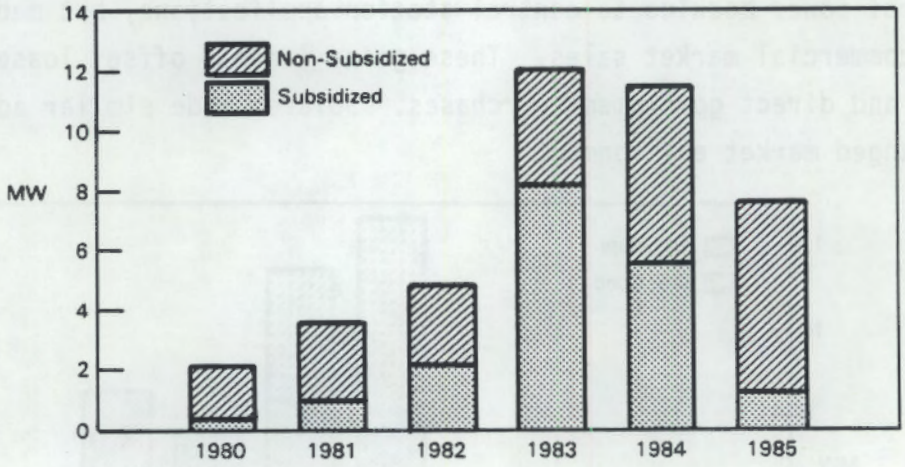


FIGURE 2.5. Subsidized and Non-Subsidized U.S. Shipments

There were substantial increases in the domestic and export market for conventional, stand-alone PV applications in 1984 and continued strength in these market sectors during 1985, increasing from about 4 MW in 1983 to about 6.2 MW in 1985. These increases would be larger except for the relatively strong dollar and the continuing shortage of money in the international markets and the increased competition from European, Japanese and internally protected subeconomic production in some markets.

Overall, the U.S. share of the market dropped from 58% in 1983 to 50% in 1984 and then to 37% in 1985 (Figure 2.6). The U.S. share is expected to drop further to 35% in 1986 due to decreased subsidized shipments.

During the early 1980's, module prices for large government purchases were in the range of $10 to $12/Wp. By 1983, module prices bid on large contracts had fallen to about $5/Wp (SMUD II bids). Throughout 1984, price

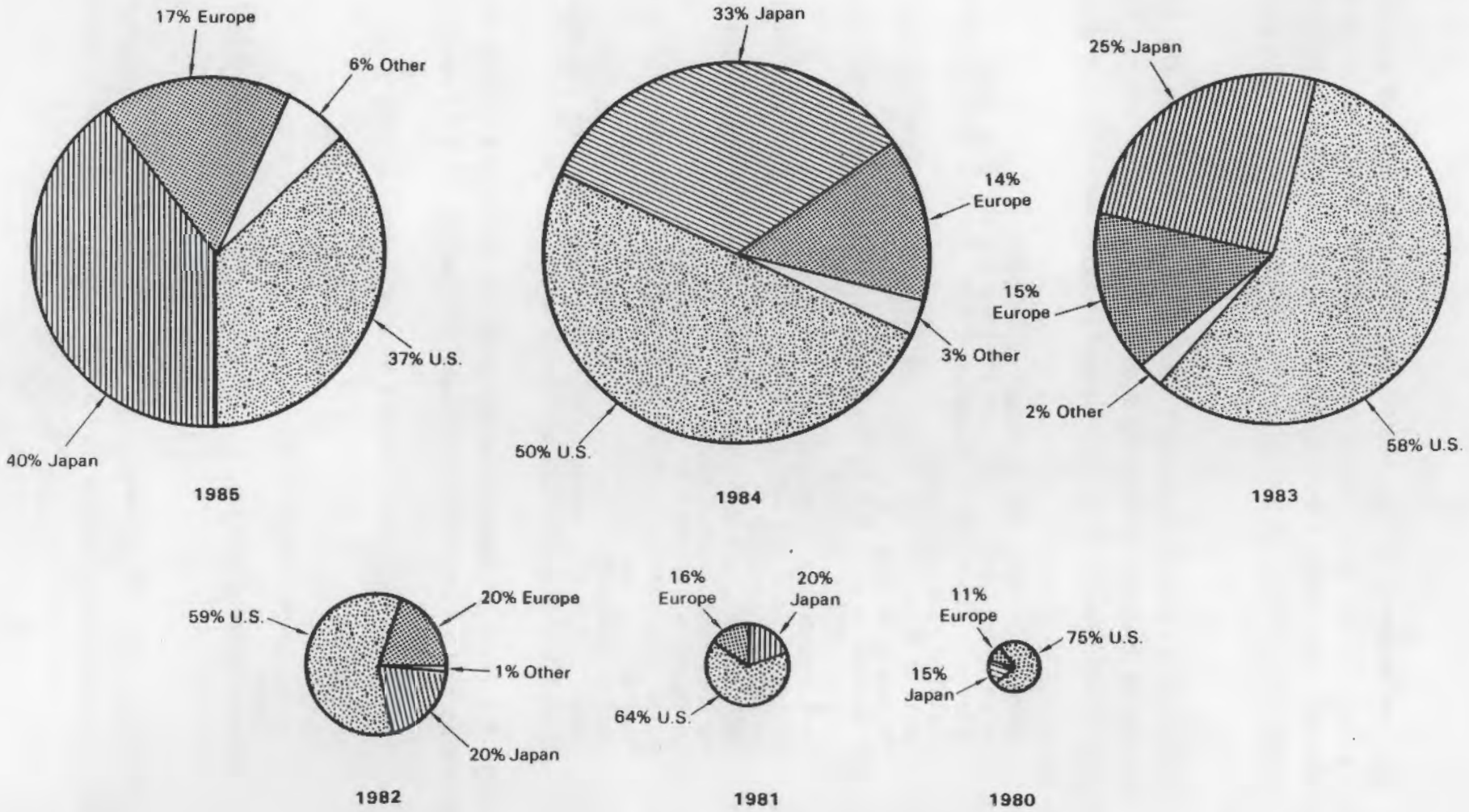


FIGURE 2.6. World PV Market Share

competition was moderate at the retail level. During 1985 and the first half of 1986, prices at the retail distributor level for quantities of in the range of 100 modules, had fallen from about $7/Wp to a little more than $5/Wp due to increased competition. A 300 kW grid connected system was bid at $8.88 Wp in 1985.

PV production costs have not declined sufficiently during the last 3 years to provide adequate profits to module manufacturers. Unprofitable operations forced several firms to reorganize their ownership arrangements including:

- Photowatt - left the PV industry in 1983
- Solar Power Corp. - left the PV industry early in 1984
- Solarex - purchased by Standard Oil of Indiana (AMOCO) in 1983 (Solarex name continued)
- Applied Solar Energy Corp. - shifted emphasis from terrestrial PV to space in 1982
- E-Systems - sold its PV division to its employees, who renamed the company ENTECH in 1983
- Martin-Marietta - left the PV industry in 1984
- Solarex - laid off 100 employees in 1984 and further consolidated operations in 1985
- ARCO Solar - laid off approximately 140 employees in 1984 and further consolidated operations in 1985
- Solenergy - left the PV industry in 1985
- Solec International - Pilkington Bros. withdrew from Solec (sold interest to the founder)
- United Energy Corporation - filed for Chapter 11 in 1985
- Sovonics (jointly owned by SOHIO and ECD) is being disbanded with operations consolidated at ECD in 1986.

Table 2.4 lists PV module manufacturers in the United States during 1986. The following section provides background information on U.S. manufacturers.

Table 2.4. U.S. Module Manufacturers in 1986

ARCO Solar	Mobil Solar Energy
Chronar	Solarex Corporation
Energy Conversion Devices	Solavolt International
Entech	Solec International
Free Energy Systems	Tideland Signal Corporation
Intersol	

ARCO Solar, Inc. This company is the U.S. leading PV manufacturer and is a wholly owned subsidiary of ARCO Solar Industries, a subsidiary of the

Atlantic Richfield Company. In 1978, ARCO Solar, Inc., purchased a small PV manufacturer, Solar Technology International, which had been founded 3 years earlier. ARCO proceeded to install a modern, automated assembly line to produce single-crystal silicon (CZ) cells and modules.

In January 1980, ARCO signed a multimillion dollar product development and licensing agreement with Energy Conversion Devices, Inc. (ECD), aimed at accelerating the commercialization of EDC's a-Si thin film devices. In May 1981, ARCO decided to allow the ECD PV contract to expire and decided to support its own a-Si R&D.

During 1983, ARCO built the first 1 MW central station PV system in Hesperia, California using CZ technology and announced plans for a 16 MW PV facility at Carissa Plains. In 1984, ARCO introduced the world's first commercial a-Si power module, the "Genesis". This module is more than 5% efficient and carries a 1 year warranty. ARCO also increased the warranty on many of its single-crystal silicon power modules to 10 years, and received the Underwriter's Laboratory approval on its M53 and M73 modules. ARCO laid-off about 140 of their 600 employees during 1984; however, most lay-offs were not in research areas.

During 1985, ARCO continued an aggressive approach to selling CZ while strengthening their a-Si product line. They were awarded the 300 kW contract for the city of Austin, Texas at a price of $8.88 Wp for the entire system, utilizing CZ modules. They announced a 30 watt a-Si monolithic power module early in 1986. In addition ARCO has announced translucent a-Si film modules for a variety of uses such as in automobile sun-roofs, clocks and other consumer products. They have announced consolidation of their a-Si production facilities at Camarillo, California and have increased capacity to 1 MW/yr. Plans are proceeding for a larger a-Si plant having 20-50 MW/yr capacity. The new plant is scheduled to start operation in 1988.

Chronar Corporation. This company is a major supplier of equipment to manufacturing ventures. This company was incorporated in 1976 with the purpose of developing commercial PV manufacturing facilities. To date, Chronar has developed a batch process for producing a-Si cells and modules. PV production

equipment has been sold to several organizations through joint venture agreements with Chronar.

- AFG Industries - In 1983, AFG Industries signed an agreement to install a 1 MW production line in Tennessee. Chronar retained 51% ownership and AFG 49%. Financing for the sale came from $5 million in industrial revenue bond.

- Port Jervis, New York - Chronar and a group of private investors joined together to establish a batch processing facility. This $6 million installation was opened in December 1984.

  An important milestone in the use of a-Si in power modules was established in June 1986 with the completion of a 100 kW installation for Alabama Power. The modules were manufactured in the Port Jervis, New York plant.

- Alabama Power - Is a subsidiary of the Southern Company that signed an agreement with Chronar in March 1984 to build a batch processing facility. Alabama Power will pay $6.1 million for 85% ownership in the joint venture, and Chronar will pay $1.1 million for a 15% ownership share.

- Chronar Ltd., Bridgend Wales - This wholly owned subsidiary was financed through grants and low interest loans from Wales. The 1 MW facility opened April 17, 1985.

- Chronar France - This plant is owned by Chronar, SOMDIAA, Charbonnages de France, and Groupe Drout. The $10 million, 1 MW facility went online by late 1985.

- Chronar China - This facility will cost $10 million and will have a production capacity of 1 MW/yr.

  During 1984, Chronar increased their systems capability, acquiring Tri-Solar Corporation, an experienced manufacturer of PV-powered pumping systems. In 1985 and 1986 they announced a number of PV systems and consumer products powered by a-Si.

Chronar's stock is sold through the over-the-counter market and is reported in the NASDAQ exchange under the symbol CRNR. The closing bids for Chronar stock during 1984 went from a low of $6.50/share to a high of $21.25/share. In May 1986, the stock had a market value of $13.50/share.

Energy Conversion Devices (ECD). This company manufactures a-Si power modules. ECD was established in 1960 and has developed a continuous roll production technique for a-Si cells. The development of this technique was partially funded by $9.3 million received from ARCO in 1980. This technology was incorporated into the production equipment that was sold to a Sharp/ECD joint venture of Japan.

ECD established two partnership agreements with Standard Oil of Ohio (SOHIO), (1981), a technology partnership and an operating partnership called Sovonics Solar Systems. The goals of these agreements are to 1) perform further research on the production of PV cells, 2) to commercialize the PV technology, and 3) to grant royalty-bearing leases. Since 1981, SOHIO has contributed $85 million to ECD through their operating partnership; however, in 1986 SOHIO announced its withdrawal from the partnership.

During 1984, Sovonics Solar Systems announced its plans to build a cell production facility in Michigan and a module assembly plant in Ohio. Sovonics also signed a memorandum of understanding with China to establish a joint venture to manufacture and market a-Si. During 1986, however, the Sovonics venture was absorbed into the ECD operation in Michigan as a result of the SOHIO withdrawal. ECD has announced that production will continue at the Michigan facilities.

ECD stock is traded on the over-the-counter market under the symbol ENER. The closing bids for ECD stock during 1984 went from a low of $20.88/share to a high of $42.00/share. In May 1986, the stock had a market value of $21.00/share. ECD currently employs 459 full-time employees, approximately 100 involved with PV.

ENTECH. Entech currently manufactures and sells PV concentrator systems that use high efficiency fresnel lens. The system that ENTECH developed can provide either electricity or a combination of electricity and hot water. In June of 1982, an ENTECH concentrator system was installed at the Dallas/Fort Worth airport. ENTECH is also actively involved in the research and development of concentrating collectors, modules and system design improvements.

INTERSOL Power Corporation. This company currently manufactures concentrating PV systems and was started by former employees of Martin Marietta Corporation of Denver. Their principle PV products include 5.4 kW concentrating arrays, PV concentrating modules, mobile systems, and 1 MW PV concentrator system.

In 1985 Virginia Electric and Power Company selected the INTERSOL 2 Axis tracker for its test facility. The tracker will be used to compare the power generated by fixed, single and double axis tracking systems.

Mobil Solar Energy Corporation. Mobil Solar manufactures PV power modules using ribbon technology. This company was originally a joint venture formed in 1974 by Tyco Laboratories, Inc. (20%), and Mobil Oil Corporation (80%). In 1983, Mobil purchased Tyco Laboratories' interest in the company and the company was renamed Mobil Solar Energy Corporation. After several years of R&D, Mobil opened a new manufacturing facility as a part of a major expansion plan to produce 10 MW per year within the next few years. In 1983, Mobil introduced a new ribbon production technology using a nonagon. This technique produces a nine-sided tube of silicon that is cut by a laser to produce rectangular cells. During 1984, Mobil was awarded a $245,000 contract to supply 37 KW of ribbon silicon modules for Phase II of the SMUD project. The parent organization, Mobil Corporation, was incorporated in 1882 and is a major energy company ($60 billion in sales in 1984), with products and services in oil, gas, chemicals, and paperboard.

Photowatt International. Photowatt entered the PV industry in 1974 as the PV division of Sensor Technology, Chatsworth, California. In 1979, Sensor Technology moved their operations to Phoenix, Arizona and Photowatt International was formed. Sensor Technology retained ownership of one-half

of the new company and GESA of France controlled the other half. GESA subsequently started Photowatt SA in France and Photowatt Afrique. In 1983, Photowatt sold its PV inventory and left the industry. Photowatt SA continues operation in France.

Solec International, Inc. This small business was started in 1976 by Ishaq Shayrayar to manufacture PV cells and modules. In 1980, Pilkington Brothers, a British glass manufacturer, purchased 80% interest in Solec. This acquisition benefited Solec because it provided the company with worldwide sales outlets. Solec's sales increased by 300%. Subsequently, Pilkington Bros. sold their interest back to Ishaq Sharayer in 1985. Currently, Solec purchases wafers and manufactures cells, panels and markets a variety of PV systems. Solec employs approximately 50 people.

Solenergy Corporation. This was a small, privately held business established in 1978 by Robert Willis to manufacture PV devices. Solenergy purchased silicon slices, produced a wide variety of products, and had a staff of 25 people. Kayex Corporation was a 20% shareholder in the company and has annual sales of about $20 million. Kayex is a General Signal Corporation company specializing in material processing equipment for the PV and silicon industries. In 1983, Solenergy merged with Entropy, Ltd. via a stock exchange, and in 1984 they signed a letter of intent with China to build a PV manufacturing plant. In 1985 Solenergy stopped manufacturing PV modules.

Spire Corporation. Founded in 1969 as a small business, this high-technology company is engaged in research, engineering, and manufacturing of PV cells and processing equipment for high-volume production of cells and modules. The company has produced cells and modules for the U.S. Department of Energy (DOE) program, but its primary interest is manufacturing PV production equipment. The company is also developing thin film processes for low-cost substrate fabrication, thin film deposition, and cell structure formation. In 1983, Spire began to sell its SPI-LINE™ system to Saudia Arabia and to India. Spire also developed a process for depositing GaAs directly onto a silicon substrate that may significantly reduce the cost of GaAs cells. Spire signed a $4 million agreement with China in 1984 to sell 1 MW of PV

manufacturing equipment. Spire sold a 1-MW PV module manufacturing system to Solarpac of Canada.

Spire Corporation stock is traded on the NASDAQ exchange under the symbol SPIR. The closing bids for Spire stock went from a low of $8.50/share to a high of $14.50/share in 1984. In May 1986, the stock had a market value of $13.00/share.

Solar Power Corporation. Established in 1969 as a small business, Solar Power Corporation was acquired by Exxon in 1975. In 1983 the company reduced the size of its production facility and distribution channels and organized to operate with less than 100 employees. Solar Power Corporation concentrated on manufacturing PV devices for today's market. Advanced R&D was conducted in other areas of the parent company. Solar Power Corporation provided the PV system for the Universe of Energy Pavilion at Disney World. Exxon Corporation, with $103 billion in sales (1980), is a major multinational integrated company in the areas of oil and gas, energy, information systems, and chemicals. The company supported considerable internal research in advanced PV materials, with particular emphasis on a-Si.

In 1983, Exxon announced that Solar Power Corporation was for sale. In 1984, Solar Power Corporation's assets were sold to Solarex and other employees were laid off. Exxon Corporation also terminated the a-Si research program in Linden, New Jersey in 1983. To date, Solar Power Corporation has not been sold. Solarex is providing service to Solar Power Corporation customers.

Solarex Corporation. Solarex Corporation entered the PV industry in 1973, and soon became known for its technological leadership with developments such as the most efficient solar cell, the first high-density modules, vertical junction cells and the ultra light 2-mil cell for space PV applications. The most significant development was the semicrystalline silicon material for solar cell use. Prior to this development single-crystal silicon was the only material used for solar cell mass production. Solarex started a wholly owned subsidiary, Semix, to manufacture the semicrystalline material.

Until 1983, Solarex was a widely held company with corporate investors from countries such as Italy, Holland, and France. In 1983, Solarex became a totally

owned subsidiary of Standard Oil Company (Indiana) and Semix became a division of Solarex Corporation. Solarex has a manufacturing facility in Australia (Solarex Pty) and one in Hong Kong (Solarex Electric) for consumer products. It has a sales office in Milan Italy to handle sales in Europe, the Middle East, and Africa in addition to sales outlets coast-to-coast in the United States.

In 1983, Solarex acquired RCA's a-Si technology and formed the Thin Film Division. The Solarex Thin Film Division was the first U.S. company to commercially manufacture and ship amorphous products. Solarex also has an Aerospace division that manufactures solar cells for use on satellites and spacecraft and recently was chosen to supply the PV modules for NASA's COBE spacecraft. In 1984, Solarex introduced the industry's only minimum wattage guarantee for PV modules. Solarex had approximately 600 employees in 1984. The number of employees decreased in 1985 and 1986 while production has increased and reflects improved operating efficiency. Solarex shipped the first a-Si cells for use in calculators made in the United States and continues an aggressive program to increase the efficiency of its production cells and introduce them in other markets.

Solavolt International. This company was formed as a joint venture between Motorola ($5 billion in sales in 1984) and Shell Oil Company subsidiaries ($21 billion in sales in 1984) in 1981. Both companies had been working in PV since the mid-1970s.

Solavolt originally had two divisions: one to concentrate on thin film technologies and the second to develop their continuous ribbon production process. The thin film research was phased out in 1983. Currently they use conventional and polycrystalline silicon technology to produce high-quality modules. Production of these modules allows Solavolt to gain both production and marketing experience. Solavolt is expected to introduce their ribbon modules within the next year, which will replace polycrystalline modules with very similar performance, reliability and life characteristics. Solavolt had 175 employees in 1984 and continues at about the same employment level.

Tideland Signal. Tideland has supplied PV systems for powering offshore navigational aids since 1972. Tideland developed and patented a very durable all-glass solar module. Cells for these modules were manufactured by Tideland Energy Pty., Ltd., a wholly owned subsidiary in Sydney, Australia. More than 12,000 Tideland Solaviva navigational aids have been installed worldwide. Tideland also has wholly owned subsidiaries in Canada, Mexico, and the United Kingdom. Tideland Pty., Ltd., was sold to BP Solar in 1985. Tideland continues operation in the United States.

United Energy Corporation (UEC). UEC, a privately owned enterprise operated under the leadership of Ernest Lampert, originated in Hawaii in 1978. UEC began the manufacture and sale of PV panels and systems. In 1981 the company moved its primary operations to California where it became a diversified developer and manufacturer of renewable energy equipment systems.

UEC marketed a solar electrothermal generator equipped with Point Focus Fresnel Lenses and actively cooled PV concentrator cells. The generators were mounted on a dual-axis tracking system rated at 2.5 kW and 33,000 Btu per hour. 1984 sales of this product were reported to be approximately $45 million, placing UEC second in the world ranking of PV manufacturers. The company had a staff of 1500 employees during its period of peak production. UEC vertically integrated its manufacturing operations. Manufacturing units were located in California (Foster City), Mexico (Mexicali) and India (Madras).

The majority of their sales have been financed through third-party arrangements. Two of UEC's major sites during 1983 and 1984 were Barstow and Borego Springs, California. Their production was almost wholly financed through these third-party arrangements. The third-party arrangements fell into disfavor late in 1984 and production was halted. The company sought Chapter 11 protection. Production at UEC has not resumed during the first half of 1986.

UEC sponsored "The Solar Revolution," an educational program describing the many benefits of using renewable energy resources.

2.2 Japanese PV Industry

The Japanese PV industry has grown rapidly over the past five years from .5 MW of commercial shipments in 1980 to 8.1 MW in 1985 (Figure 2.7).

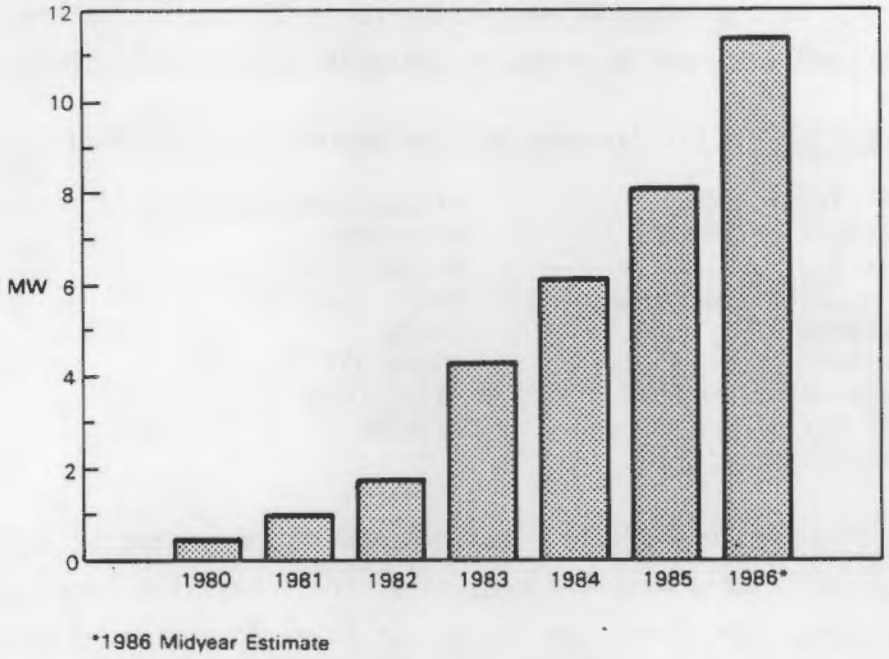


FIGURE 2.7. Japanese PV Shipments

Japanese shipments are expected to increase to 11.4 MW in 1986 based on a mid-year estimate. However, unlike U.S. shipments, about 80% of the Japanese sales are to the non-subsidized, consumer goods market which include watches, calculators, etc. The Japanese companies have viewed this market as a testing ground for developing their thin film technology, as well as a means of expanding their PV production base. By concentrating on the consumer goods market, the Japanese share of the world PV market has increased from 15% in 1980 to 40% in 1985 (Figure 2.6).

Although the Japanese have increased their share of the world PV market, they are still behind the rest of the world in producing large-scale PV power modules. However, they are in the process of closing the gap; they are developing and producing more single-crystal and semicrystalline modules and are making a determined bid to penetrate the U.S. market with an attractive product line. They apparently do not intend to risk exclusion from the power market by limitations subsequently encountered in the perfection of high-

efficiency a-Si power modules. The Japanese government is providing money through the Sunshine project to eliminate this technology gap.

Table 2.5 lists the Japanese manufacturers in 1986. The following section provides background information on major Japanese module manufacturers.

TABLE 2.5 Major Japanese Module Manufacturers in 1986

Fuji Electric Co.	Mitaka Electronics
Hitachi Electric Co.	Mitsubishi
Hoxan Co.	Nippon Electric
Japan Solar Energy Co	Sanyo Electric
Kanekafugi	Sharp
Kodenshi	Showa Oil Co.
Komatsu Electronics	Taiyo Yuden
Kyoto Ceramic	Toshiba
Matsushita Electric	

Fuji Electric was one of the first Japanese PV companies to fabricate large area a-Si cells on a metallic substrate. Fuji has also constructed a PV residence that uses 3 kW of modules and a Fuji Power conditioning system. During 1984, Fuji signed an agreement to share a-Si developments with Photowatt of France. Fuji is the second leading world producer of a-Si modules for use in calculators and watches.

Hoxan started in 1929 in Sapporo, Hokkaida Province as an oxygen production plant. Hoxan has grown to be a manufacturer of a wide range of industrial and specialty gases, liquid petroleum gas, medical gases and handling equipment.

In 1963, in a joint venture with American Standard, they began production of Bath-All bathroom units.

In 1982, Hoxan entered the PV industry with modest production. They recently have dedicated a 9 MW, fully automated PV production facility. This facility claims to be the largest PV manufacturing facility in the world; it converts single-crystal silicon slices into 36-cell, 40 W modules. A unique feature of this plant is that no people ever contact the modules or cells.

Hoxan and American Standard of the United States have announced a joint venture to market PV in 1986.

Kyocera entered the photovoltaics industry in 1979 and has produced modules in the four major PV technologies: polycrystalline silicon, single-crystal silicon, a-Si and ribbon. Their ribbon PV technology was developed through a joint venture with Mobil Solar (then Mobil Tyco) in 1979. Kyocera entered the U.S. market vigorously in 1984 selling both modules (multicrystalline) and systems.

Sanyo is reported to be the leading producer of PV in Japan. Sanyo has established an energy division involved in both PV and solar thermal technologies. It constructed a $50 million PV production plant capable of producing more than 1 million calculator-type modules per month.

Sharp has been in the PV business longer than any other Japanese firm. Currently, Sharp is the principal manufacturer of PV cells for Japanese spacecraft. The company is also involved in manufacturing crystaline cells and modules for use in remote stand-alone applications and a-Si pocket calculators.

They joined ECD (USA) in a venture with Sharp-ECD developing a roll-to-roll a-Si production machine that fabricates a-Si cells on a 180 cm wide stainless steel sheet.

2.3 European PV Industry

Shipments of PV modules by European firms increased from 0.3 MW in 1980 to approximately 3.5 MW in 1985 (Figure 2.8). There appears to be a slight growth in shipments between 1984 and 1985 in spite of greatly reduced purchases of modules by the Commission Of European Communities (CEC). The CEC has assisted European PV manufacturers in establishing 15 pilot projects under cost sharing arrangements. The major portion of these shipments occurred in 1983 and 1984; therefore, maintaining modest overall growth required substantial increases in nonsubsidized shipments. The reduction in purchases in 1985 by CEC resulted from delays in finalizing the budget for PV projects for the next five years.

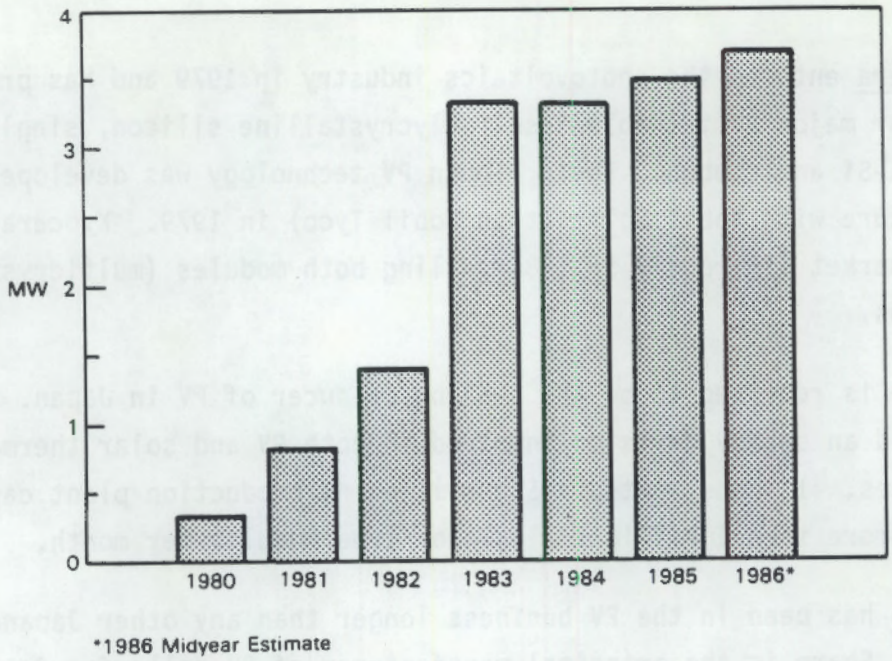


FIGURE 2.8. European PV Shipments

Table 2.6 lists major European module manufacturers in 1986. The following section provides background information on these manufacturers.

TABLE 2.6 Major European Module Manufacturers in 1986

AEG	Isophoton
Adriatica Componenti	Photowatt SA
Ansaldo	Pragma
BP Solar	Siemens A.G.
Helios Technology	

AEG. AEG has been involved in PV for the past 20 years and is currently Germany's largest PV manufacturer. In the past, AEG purchased polycrystalline Si from other manufacturers for their PV modules. However, AEG has been working with Heliotronic, a Wacker Chemitronic subsidiary, on the development of low-cost polycrystalline silicon.

Currently, AEG markets a wide range of PV systems such as hazard beacons, water pumping systems, and telecommunications relay stations. AEG was the primary contractor for the 300 kW Pellworm Island PV system that was partially funded by the CEC.

Ansaldo. Ansaldo is a state-owned electromechanical company appointed by the government of Italy develop and produce energy systems. They manufacture their own single-crystalline cells and produce PV modules. Currently, PV

production capacity is about 200 kW. Some research is being conducted on a-Si; however, they have no plans to introduce a-Si modules in the near future. Ansaldo has been involved in the construction of a kW size, hybrid thermal/PV plant in Australia.

BP Solar. Prior to 1983, BP Solar was a joint venture between British Petroleum (BP) and Lucas. In 1983, BP purchased Lucas' interest in the company. Currently they purchase cells and produce modules. Their marketing objective is to sell complete PV systems not individual modules. In 1983 BP Solar began installing the largest PV system in the U.K. near Southampton. The 30-kW installation is estimated to cost $1.5 million and is financed by BP Solar and the Department of Industry. During 1984, BP Solar acquired the film division of Monosolar as well as the technology to manufacture the mercury, cadmium, and tellurium cells.

In 1985 BP Solar acquired the Tideland Energy Pty., Ltd., manufacturing plant from Tideland USA. Giving them an Australian manufacturing capacity of 100 KW per year.

BP Solar is marketing aggressively in the communications field in 1985 and 1986. BP Solar announced sale of 5000 modules to Peru for 38 microwave repeater stations. The total installed capacity is to be rated at 165 KW.

France Photon. France Photon is a wholly owned subsidiary of Leroy-Somers, a medium-sized electrical company with 4000 employees. The subsidiary was formed in 1978 to produce single and polycrystalline cells and modules using the Solarex technology. The design and marketing of complete PV systems is performed by two other Leroy-Somers groups: Pompes Guinard and Systemes Solaires. France Photon has built a 44 kW village electric system at Rondolinu Cargese, Corsica. France Photon was ordered to merge their PV operations into Photowatt SA in 1985.

Helios. Helios is located in Italy and is one of the few non-oil, nongovernment-funded module producers in Europe. Helios purchased PV technology from Solec International and has an advanced, low-cost, automated cell and module manufacturing line. They report that their cell production process is unique in that wafers are etched until small tetrahedra are formed on the

surface, thus reducing reflection and increasing efficiency. Helios has been a major cell supplier for BP Solar, and they have concentrated their marketing efforts in southern Europe.

Photowatt, SA. This company is a subsidiary of SAFT (CGE group), ELF (a major oil company) and RTC (the Philips group) with its headquarters located in Revie - Malmaison, near Paris. Photowatt has also established Photowatt Afrique, in Abidjan, Ivory Coast, to sell small PV-powered systems to neighboring countries. In 1984, Photowatt took steps toward commercializing the "polyx" ingot casting process developed by Photowatt and Laboratories de Marcousses. Photowatt manufactured about 50% of their modules in 1985 using Polyx multicrystalline silicon, and 100% of their modules in 1986. By switching to the Polyx multicrystalline, Photowatt expects to be able to achieve the PV cost reduction goals set by the government agency, Agence Francaise Pour la Maitrise de l'Energie, of $2.75/Wp.

Pragma. Pragma of Italy was formed by the state-owned oil company ENI. Pragma originally owned a share of Solarex and therefore had access to the technology for producing "Semix" polycrystalline material. Pragma also owns a controlling interest in Solarix, an Italian licensee of Solarex. Pragma has assembled both single-crystal and polycrystalline modules. They are working on a-Si. They reported at the end of 1983 that they had sold their production quota for 1984. Previously they had announced a capacity of 450 kW per year. They built an automated assembly plant for cells and modules capable of producing 2 MW/yr.

Siemens A.G. Interatom is a subsidiary of Siemens that is responsible for all PV research, product development and marketing. Siemens' product development strategy has four major elements:

- quality single-crystal modules,
- R&D on low-cost silicon purification, using arc furnace technology
- high speed ribbon production using web-supported horizontal growth
- a-Si R&D.

Their single-crystal product is marketed worldwide and is used for communications, battery charging, remote residential power, etc. Siemens currently employs approximately 40 professionals in its PV business.

2.4 "OTHER" PV REGION

The "other" PV region includes primarily those PV companies in Asia and South America. The growth in PV activity in this region has been modestly increasing from 400 kW in 1983 to a little over 1-MW in 1985. Two companies are responsible for much of the growth of this region: CEL and Heliodynamica.

CEL (New Delhi, India). CEL is a government-owned PV manufacturer that produces crystalline PV cells, modules, and systems. The technology used was developed in the United States, but the production equipment was made in India. CEL has developed and manufactured PV systems for offshore well-head platforms, telecommunications, weather monitoring and various other industrial applications.

Heliodynamica. Located in Cotia (22 miles from Sao Paulo) Brazil, this company is a privately owned PV manufacturer that entered the PV industry in 1980. Heliodynamica is the first Third World company to manufacture cells, modules and complete PV systems.

They installed Brazil's first PV powered water pumping system in 1981 at Rio Grade do Norte. The company has since developed a new motor for its submersible tube well pump as well as an extremely simple priming device for its surface-mounted pumps. Telebras, the government telecommunications company, is replacing many of its diesel generators at remote sites with PV powered systems, supplied by Heliodynamica.

3.0 TECHNOLOGY TRENDS

During 1985, commercial PV modules were made from cells using five different technologies: single-crystal silicon (CZ), amorphous silicon (a-Si), semicrystalline silicon, concentrators, and ribbon. Single-crystal silicon continues to be the dominant PV technology with 48% of the market in 1985 (Figure 3.1). CZ production has been quite stable (approximately 10 MW) over the period of 1983, 1984, 1985 and appears to be likely to exceed that level again in 1986 (Table 3.1). This stability in the face of challenges by other technologies reflects its continued strength in a number of market sectors.

Table 3.1. Distribution of PV Shipments by Technology

Technology	1980	1981	1982	1983	1984	1985	1986*
Single Crystal	1.9	2.5	4.5	9.9	9.6	9.9	11.1
Semicrystalline	1.0	1.3	2.1	3.2	4.5	4.5	5.5
Amorphous Silicon	0.3	0.6	0.8	3.0	4.3	5.8	8.0
Concentrators	0.0	0.9	0.9	4.6	3.1	0.1	0.1
Ribbon & Other	0.1	0.1	0.1	0.1	0.1	0.2	0.3
Totals	3.3	5.4	8.4	20.8	21.6	20.5	25.0

* Based on mid-year 1986 estimate.

Semicrystalline cells were used in module production in steadily increasing quantities from 1980 to 1984. Further increases are expected in 1986 (mid-1986 estimate). The efficiency of this technology has increased steadily with production modules being about 1 percentage point less efficient on an area basis compared to CZ modules.

Together these two technologies have accounted for about two-thirds of the total market for 1983 to 1985 and are expected to continue to do so through 1986. Their market share might have eroded more rapidly than has actually occurred if both technologies had not made substantial progress in their conversion efficiencies. Their reliability has been so outstanding and their progress in increased efficiency is so substantial that they continue to set the standard for other developing technologies to match.

Amorphous silicon, thin film, shipments have been growing steadily due to the consumer goods market but, they have not yet penetrated seriously into

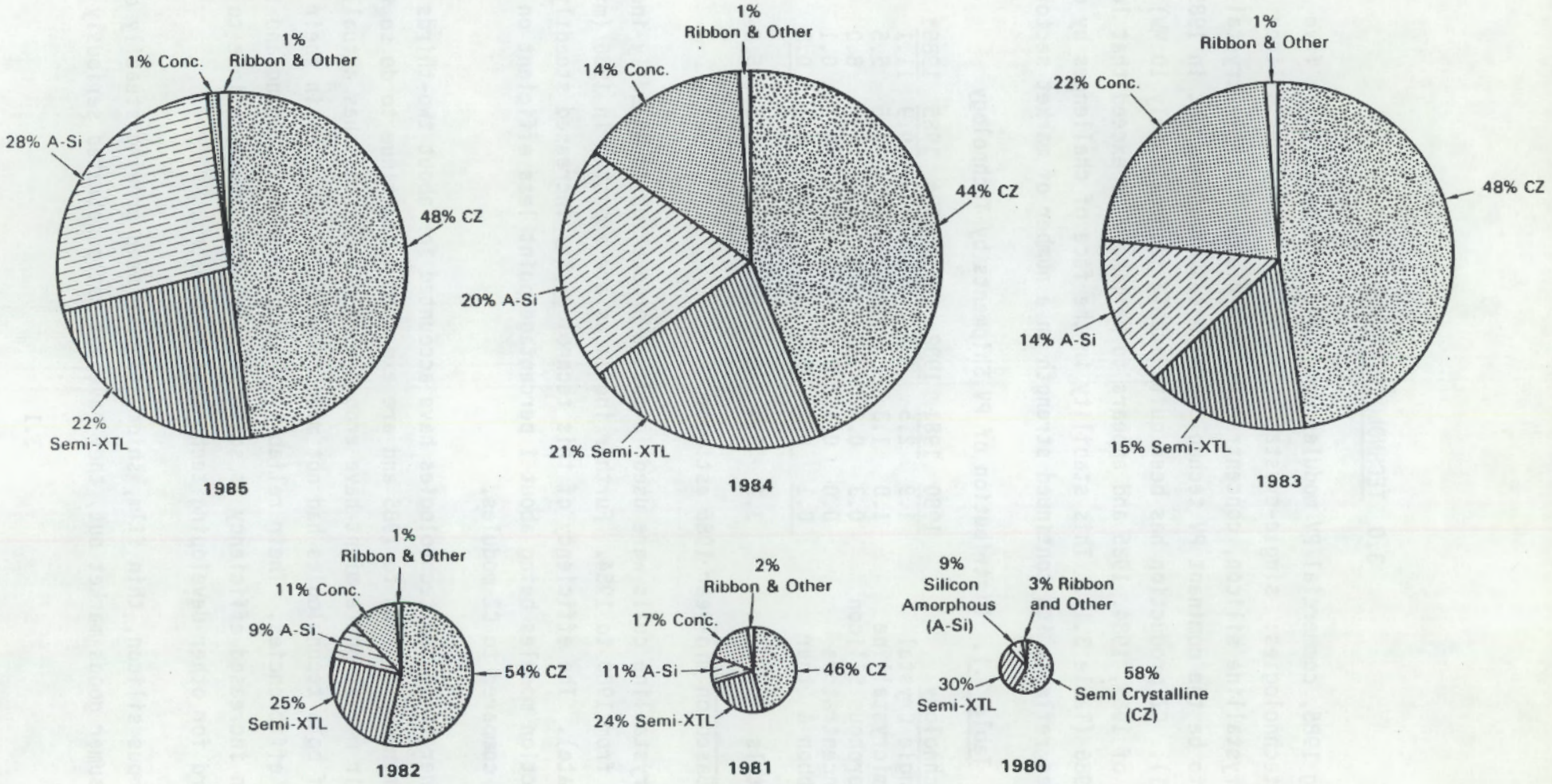


FIGURE 3.1. Technology Distributions of World PV Shipments

the power module market. This may change as modules larger than about 5 W were available for the first time in 1985 and 1986. Most of these larger modules go to a few selected applications where their performance and stability can be monitored carefully. These modules may begin to penetrate some of the present flat plate market sectors in 1987. Other sectors such as communications and corrosion protection will probably continue for some time to come to use products that have gone through a lengthy qualification procedure. Amorphous silicon is expected to penetrate first into those markets where efficiency doesn't directly affect the computed balance of system costs. Numerous applications not yet widely used by the conventional technologies could greatly increase the size of this market. Some of the uses being considered include automotive applications to provide battery topping and ventilation to locked vehicles.

The concentrator technology has not yet penetrated the PV marketplace except when purchased by the government for research purposes or as a "tax shelter" package. The lack of interest in concentrator systems is attributed to the view, held by many small system buyers, that concentrators are technically more complicated than flat plate systems. Larger systems have involved federal tax credits or other forms of subsidy. In the recent legislative climate, tax incentives and other subsidies have become less attractive, causing a loss of most of the concentrator market. Brilliant technical achievements in increasing the efficiency of concentrator systems have not been able to counter this trend.

Other technologies including ribbon technologies have achieved modest market penetration (300 kW). The ribbon technologies have great potential for cost reduction compared to the costs for making conventional CZ or semicrystalline cells. The ribbon technologies have made considerable progress in improving the technology and reducing the manufacturing cost. They have more than matched the efficiency and expected costs of the CZ modules of the past. In 1986 Westinghouse announced plans for increasing the capacity of their dendritic web ribbon pilot line. They are, however, aiming at a moving target due to the great progress made by CZ and semicrystalline technology. Other technologies such as thin films have made no significant penetration of the power module market. Table 3.2 lists PV manufacturers using CZ technology

in 1986. Table 3.3 lists manufacturers using semicrystalline technology and Table 3.4 lists manufacturers using a-Si technology.

TABLE 3.2 PV Manufacturers Using CZ in 1986

Ansaldo	Komatsu Electronics
ARCO Solar	Nippon Electric
BHEL	
BP Solar	Photowatt SA
Central Electronics Ltd.	Pragma
Continental Devices	Sharp
Energia Tideland	Showa Oil Co.
Free Energy Systems	Siemens AG
Heliodynamica	Silicon Sensors
Helios Technology	Solec International
Hoxan	Spire Corporation
Isophoton	Tideland Signal
Kodenshi	

TABLE 3.3 PV Manufacturers Using Semicrystalline Technology in 1986

Adriatica Componenti	Kyoto Ceramic
AEG Telefunken	Pragma
Hitachi	Solarex Corporation
Hoxan	Solarex Pty. Ltd.
Japan Solar Energy	Solavolt International
Komatsu Electronics	

TABLE 3.4 PV Manufacturers Using a-Si Technology in 1986

ARCO Solar	Sanyo Electric
Chronar & Licensees	Sharp
ECD	Solarex
Fuji Electric	Taiyo Yuden
Kanekafuji	Tenjin Ltd.
Kyoto Ceramic	

Only two companies, Entech and Intersol, are known to be shipping PV concentrators in 1986. Mobil Solar, Westinghouse of the United States and Toshiba of Japan are the only firms known to be shipping ribbon products in 1986. Solavolt International is expected to begin shipping Ribbon To Ribbon (RTR) products in the near future.

In summary, CZ and semicrystalline technologies are competing with each other for the same market sectors on the basis of price and efficiency. Both

technologies are stable and reliable. Amorphous silicon has grown rapidly, primarily in the consumer goods market where efficiency and longevity are less important than in power module applications. Amorphous silicon shipments have grown by carving out new market niches rather than by taking shares of established markets. Growth in the immediate future will likely follow this pattern. After a-Si efficiency, stability and reliability are adequately demonstrated, existing market sectors may become a serious target for a-Si penetration. Concentrator and ribbon technologies are not significant factors in the market at this time; however, they may become more important in the future. The interdependence of technology and market sectors are discussed below.

4.0 MARKET SECTOR COMPARISONS

This section subdivides the annual shipments of PV modules by final end-use. Estimating the shipments to end-use sectors is extremely difficult because modules are often sold by the manufacturer to distributors or importers who then sell the modules to dealers or to the ultimate customers. In such cases, the original manufacturer may have little information on the final end-use of the product. The market sector designations used in this section resulted from a cooperative effort of PNL, the Jet Propulsion Laboratory (JPL) and the Energy Information Administration. Definitions of the market sectors used are given below to assist the reader in interpreting the end results.

End-use market sectors are used to help determine the amount of PV being installed in large and small, grid vs. nongrid connected applications. These sectors include:

- stand-alone applications-includes private residences, commercial establishments, and agricultural power systems that are not connected to an electrical power grid.
- Grid connected residences-includes single and multiple-family residences that generate a portion of their power requirements and use the existing power grid for additional power. Any surplus power generated by grid-connected PV systems is sold back to the utility.
- Grid-connected, intermediate sized, commercial applications-includes power generation for use in local retailing, manufacturing, or service applications. Excess power is sold back to the utility.
- Central station-includes facilities that produce power for sale to local utilities as well as those owned by the utilities.
- Consumer products-includes applications on calculators, watches, and small battery chargers as well as other small appliances.

Transportation applications are presently included in the stand-alone sector. In the future, these applications may grow to the point where they warrant a separate category. The present applications that are included are on boat- and land-based RV equipment.

The time series breakdown of market sectors by end-use is presented in Table 4.1.

TABLE 4.1 Shipments to End-Use Market Sectors (MW)

Sector	1980	1981	1982	1983	1984	1985	1986*
Stand-alone	2.6	3.9	4.3	7.4	10.2	11.0	12.9
Consumer Products	0.4	0.9	1.5	3.6	4.9	6.7	8.9
Grid Residential	0.0	<.1	0.1	0.2	0.3	0.3	0.4
Grid Intermediate	0.3	0.6	0.7	1.0	0.7	0.6	0.6
Central Station	0.0	0.0	1.8	8.6	5.5	1.9	2.3
Totals	3.3	5.4	8.4	20.8	21.6	20.5	25.0

* Based on mid-year 1986 estimate.

The stand-alone equipment market continues to dominate all other markets although the consumer products sector is growing rapidly and may overtake the stand-alone market. However, the stand-alone sector is a vigorous market growing at a rate of 33% per year from 2.6 MW in 1980 to 11.0 MW in 1985 (Figure 4.1).

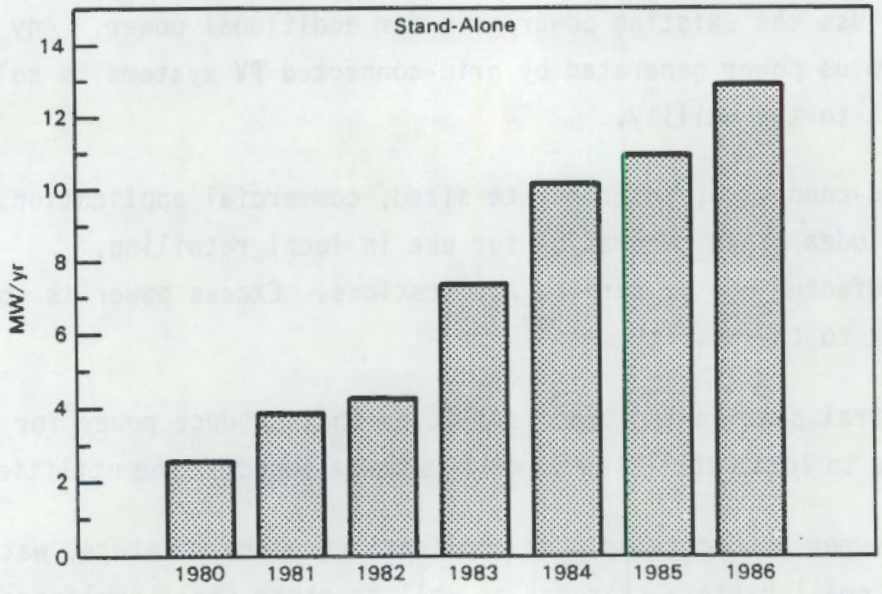


FIGURE 4.1. PV Shipments to the Stand-Alone Market Sector

Over the same period consumer products grew at a rate of 75% per year (Figure 4.2). Many stand-alone applications are far from saturated and continued growth is expected. PV-powered hand calculators may be beginning to saturate the market as they are now beginning to appear as a commercial courtesy, giveaway item. However, there appears to be a vast potential market for other consumer products using PV.

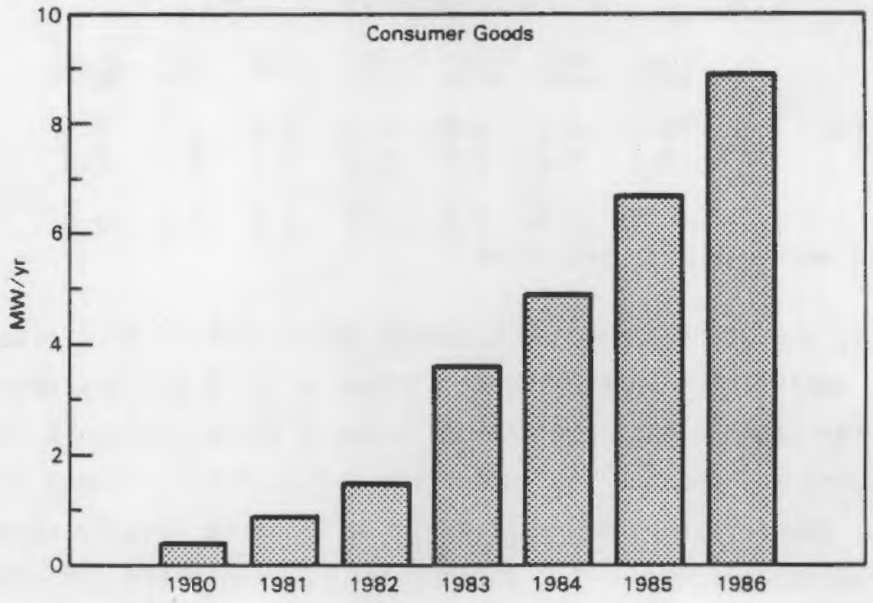


FIGURE 4.2. PV Shipments to the Consumer Market Sector

The stand-alone market segment can be further segmented into the following types of applications listed in their approximate order of decreasing importance:

- Communication
- Village power and lighting
- Pumping
- Cathodic Protection

Communication and cathodic protection are usually provided by systems suppliers: Original Equipment Manufacturers (OEMs). These customers often repeat orders. The other sectors require a dealer or distributor to invest time in designing or customizing nearly every application.

Total grid-connected shipments, including grid residential, grid intermediate and central station, rose to a peak of nearly 10 MW in 1983 (Table 4.2). The federal legislative climate became less favorable toward tax breaks or other support for PV; this caused drastic reductions in the U.S. grid-connected market sectors. Other countries such as Japan as well as those in Europe are continuing some support for these market segments.

TABLE 4.2 Grid-Connected PV Shipments

	1980	1981	1982	1983	1984	1985	1986*
Concentrator	0.0	0.3	0.9	4.6	3.1	0.1	0.0
Flat Plate	0.3	0.3	1.7	5.2	3.4	2.7	2.8
Total	0.3	0.6	2.6	9.8	6.5	2.8	2.8

* Based on mid-year 1986 estimates.

In summary, the stand-alone and consumer goods markets will likely continue to expand at a modest rate in the future with or without any government support. The potential for stand-alone applications appears to be extremely large but marketing managers say that PV still requires substantial customer education for each sale. However, they say that PV is no longer a totally strange idea. There is still considerable selling expense for new customers. Fortunately, some of the customers such as communications equipment suppliers place repeat orders.

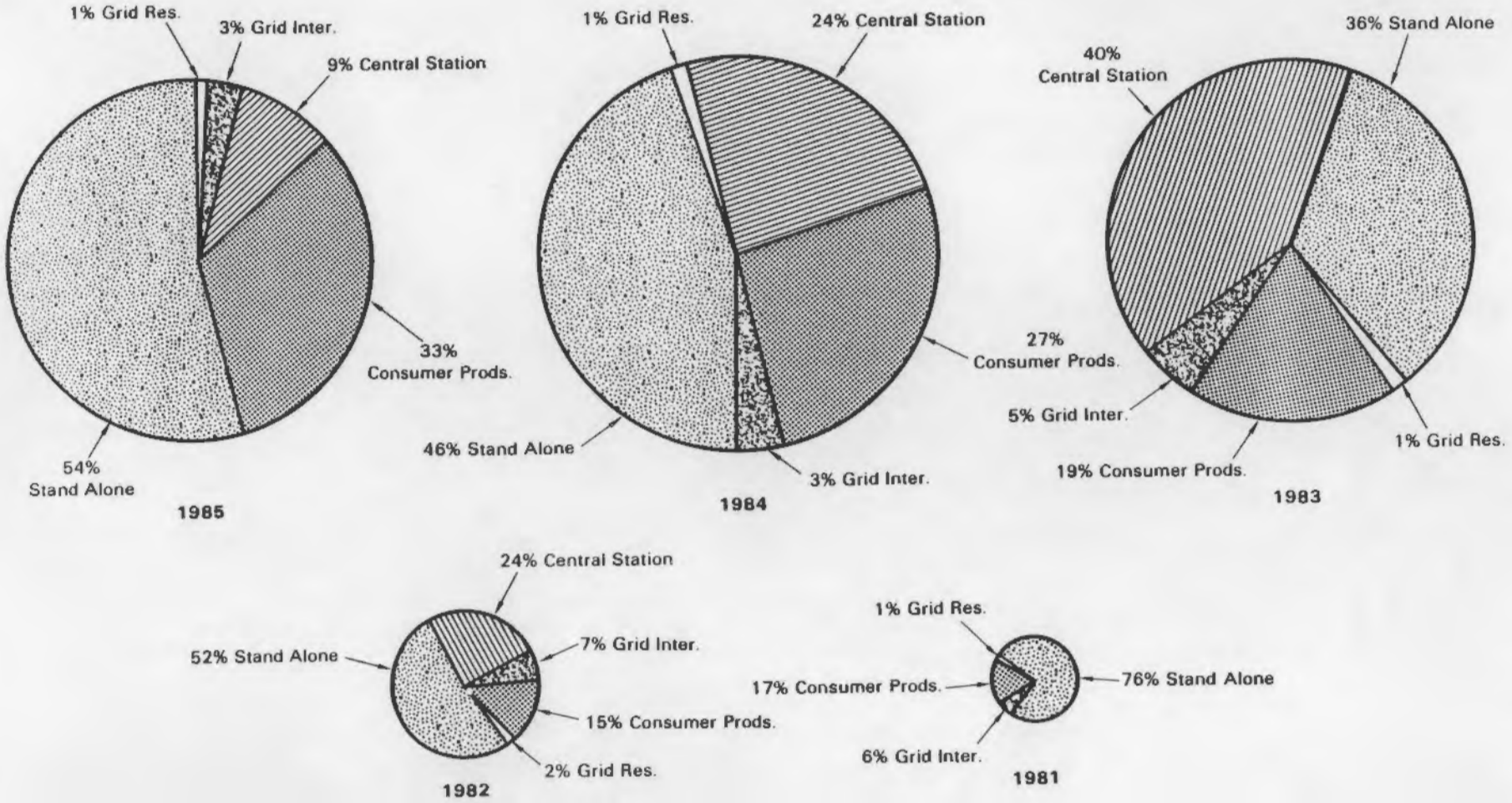
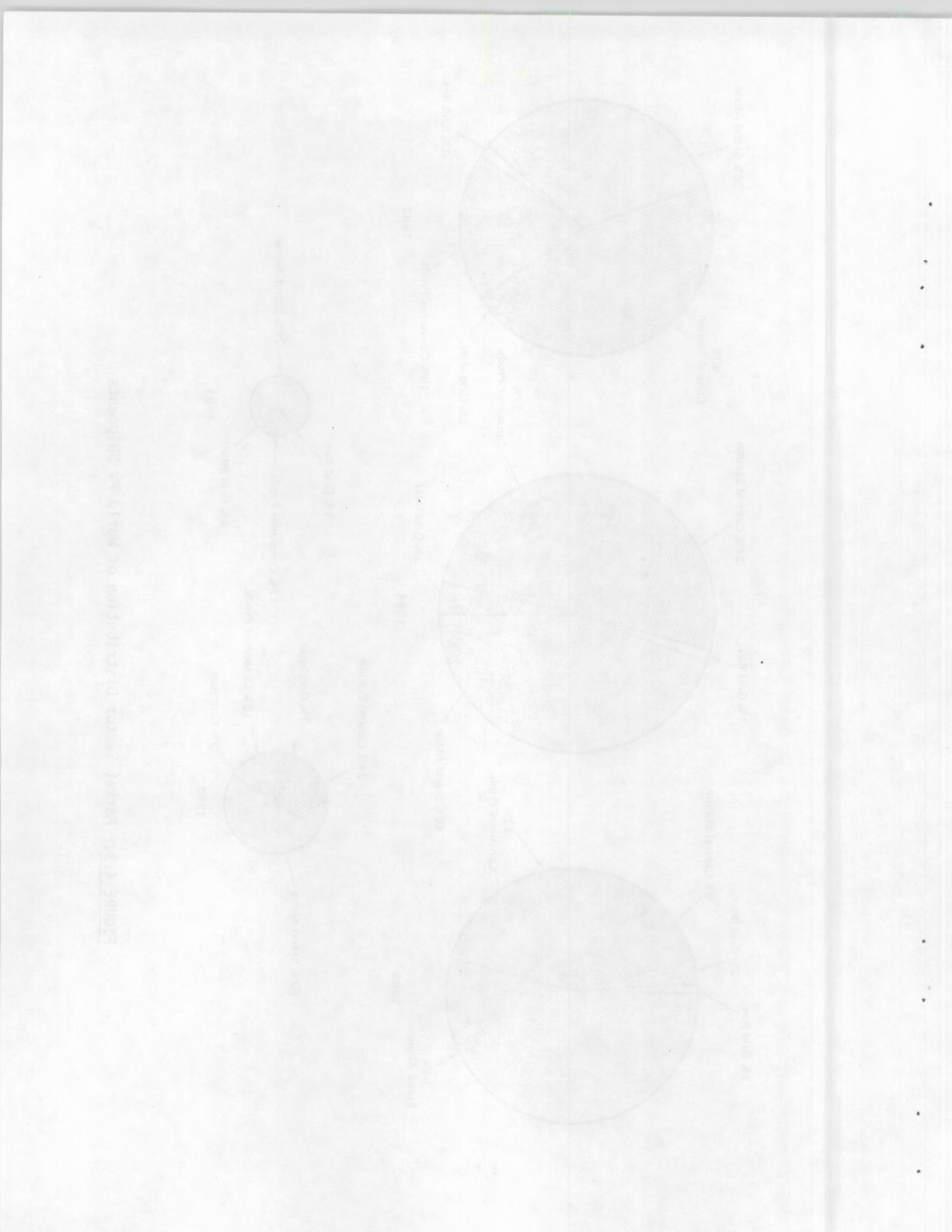


FIGURE 4.3. Market Sector Distribution of World PV Shipments



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APPENDIX A

The following is a listing of the PV industry current events for the fourth quarter of 1985 through the first 2 quarters of 1986. The events are sorted by company and chronologically.

Information for this appendix was taken from several sources including the following publications:

Abreviation	Full Publication Title
• SE&C	Solar Engineering and Contracting
• WSM	World Solar Markets
• SEIR	Solar Energy Intelligence Report
• RENEW	Renewable Energy News
• PV News	Photovoltaic News
• PV Inter.	PV International
• ASE	Alternative Sources of Energy
• Solar Age	Solar Age
• PVIR	Photovoltaics Insider Report

DATE LISTED 08-13-86

PV EVENTS 1985-86

RECORD #	1	SEIR 10/85,361	
10-28-85	ARCO SOLAR		WOODLAND HILLS

SUBMITTED A BID FOR THE 30D KW AUSTIN PV SYSTEM. BID SUBMITTED WAS FOR $9.00/WP.

RECORD #	35	SEIR 11/85,384	AUSTIN TX
11-18-85	ARCO SOLAR		WOODLAND HILLS

AUSTIN ELECTRIC DEPT HAS SELECTED ARCO FOR THE 300 KW POWER PLANT. ARCO BID $2.664 MILLION.

RECORD #	39	SEIR 12/85,423	
12-16-85	ARCO SOLAR		WOODLAND HILLS

WILL BEGIN WORK ON THE AUSTIN TEXAS 300 KW PV SYSTEM IN JANUARY 1986

RECORD #	86	SEIR 06/86,194	
06-17-86	ARCO SOLAR CORP.		CHATSWORTH

OFFERING A FULL-SIZED PV MODULE USING MONOLITHIC CIRCUIT OF THIN FILM SILICON. THE MODULE IS RATED AT 30 WATTS AND PERFORMS WELL IN BOTH DIRECT AND INDIRECT SUNLIGHT.

RECORD #	11	SE&C 11/85,11	
11-01-85	ARCO SOLAR ENERGY CORP.		WOODLAND HILLS

EXPANDING ITS THIN FILM SILICON (TFS) LINE OF PRODUCTS. PRODUCE A TRANSLUCENT MODULE FOR AUTOMOBILES BOATS CLOCKS ETC.

RECORD #	15	WSM 10/85,8	
10-01-85	ARCO SOLAR INC.		WOODLAND HILLS

EXPANDING ITS LINE OF THIN FILM SI BY OFFERING CUSTOMIZED POWER PACKS FOR CARS BOATS RVS ETC.

RECORD #	29	SEIR 11/85, 392	
11-25-85	ARCO SOLAR INC.		WOODLAND HILLS

AWARDED A CONTRACT TO INSTALL A 300 KW AC SYSTEM. ARCO'S BID WAS $132,000 LESS THAN THE ONE SUBMITTED BY ACUREX.

RECORD #	91	PVNEWS 6/86,5	
06-01-86	BOEING		SEATTLE

HAS JOINED BOEING CORP AS THEIR RESOURCE DIRECTOR. THE BOEING RESEARCH CENTER IS DEVELOPING ADVANCED CELLS FOR SPACE APPLICATIONS.

PV EVENTS 1985-86

RECORD # 141 SOLAR AGE 9/85,16
09-01-85 BOSS SCOTTSDALE
INTRODUCING THE LUMASTAR OUTDOOR LIGHT. INCLUDES A LIGHT, POL E AND SMALL PV PANEL.

RECORD # 19 WSM 10/85,12
10-01-85 BP SOLAR
IS SUPPLYING 5000 PV MODULES RATED AT 165 KW TO PERU FOR 38 M ICROWAVE REPEATER STATIONS. COST IS $2.13 MILLION.

RECORD # 77 SEIR 05/86,154
05-13-86 CENTRAL ELECTRONICS LAB. INDIA
HAS DEVELOPED A PV POWER PACK FOR USE IN VILLAGES. THE UNIT P RODUCES 2 KW WITH BATTERY STORAGE. ONE MODEL WILL POWER 15 DO MESTIC AND 8 OUTDOOR FLUORESCENT LIGHTS.

RECORD # 69 SEIR 04/86,121
04-15-86 CENTRAL ELECTRONICS LTD. INDIA
WILL SUPPLY PV MODULES TO DOORDARSHAN TO POWER TELEVISION TRA NSMITTERS. CEL CURRENTLY HAS A PRODUCTION CAPACITY OF 2 MW.

RECORD # 119 PV INTER. 1/86,16
01-01-86 CHRONAR PRINCETON
RECEIVED DOE'S NATIONAL AWARD FOR ENERGY INNOVATION FOR ITS P ORT JERVIS MANUFACTURING FACILITY.

RECORD # 61 SEIR 03/86,86
03-18-86 CHRONAR PRINCETON
WILL BUILD AND OPERATE A SILANE PRODUCTION FACILITY IN CHINA AS PART OF ITS 1 MW PV PRODUCTION FACILITY. THE PLANT WILL PR ODUCE 10 TONS OF SILANE PER YEAR REPRESENTING $10MM REVENUES.

RECORD # 32 PVNEWS 11/85,2
11-01-85 CHRONAR
IS BEGINNING TO SHIP 100 KW OF PV TO ALABAMA FOR THEIR AC TES T FACILITY. ALL PANELS WILL BE SHIPPED BY THE END OF 1985 AND THE SYSTEM WILL COME ONLINE IN EARLY 1986.

PV EVENTS 1985-86

RECORD # 134 ASE 12/85,38
01-01-86 CHRONAR CORP. PRINCETON
HAS ASKED THE SECURITIES AND EXCHANGE COMMISSION TO APPROVE A JOINT VENTURE BETWEEN CHRONAR AND ALABAMA POWER TO BUILD A 1 MW PV PLANT. LOCATION WILL BE BIRMINGHAM.

RECORD # 46 SEIR 01/86,23
01-21-86 CHRONAR CORP. PRINCETON
HAS SIGNEO AN AGREEMENT WITH CHINA TO BUILD A PV PRODICTION FACILITY WORTH $10 MILLION. THE PRODUCTION FACILITY WILL HAVE A CAPACITY OF 1 MW PER YEAR.

RECORD # 153 ASE 3/B6,44
03-01-86 CHRONAR CORP. PRINCETON
HAS SIGNED AN AGREEMENT TO BUILD A $10 MILLION PV PRODUCTION FACILITY IN CHINA.

RECORD # 103 PVNEWS 4/86,3
04-01-86 CHRONAR CORP. PRINCETON
IS SELLING $4 MILLION IN STOCK WITH PRIVATE INVESTORS.

RECORD # 98 PVNEWS 5/86,3
05-01-86 CHRONAR CORP. PRINCETON
DEDICATED A 1 MW A-SI PRODUCTION FACILITY IN LENS FRANCE.

RECORD # 146 ASE 6/86,25
05-01-86 CHRONAR CORP. PRINCETON
WILL CONSTRUCT A SILANE PRODUCTION FACILITY IN CHINA AS PART OF ITS OEAL WITH THE CHINESE TO CONSTRUCT A PV MANUFACTURING FACILITY.

RECORD # 75 SEIR 05/86,151
05-13-86 CHRONAR CORP. PRINCETON
OPENED ITS $10 MM A-SI PRODUCTION FACILITY IN LENS FRANCE. CHRONAR OWQNS 49% OF THE COMPANY AND SOMDIAA OWNS 51%.

RECORD # 142 SOLAR AGE 9/85,16
09-01-85 CHRONAR CORP. PRINCETON
CHRONAR HAS INTRODUCED A NEW LINE OF PV POWERED CLOCKS. THESE UNITS HAVE A HIGH EFFICIENCY CAPACITOR THAT WILL POWER THE CLOCKS FOR SEVERAL SUNLESS DAYS.

PV EVENTS 1985-86

RECORD # 38 SEIR 11/85,389 PRINCETON NJ
11-18-85 CHRONAR CORP. PRINCTON
NAMED ITS JOINT VENTURE WITH SOUTHERN ELECTRIC INVESTMENT CO. THE SOUTHERN CHRONAR PHOTOVOLTAIC VENTURES. THEY WILL BUILD A 1 MW, $7.2 MILLION PV ASSEMBLY PLANT IN BIRMINGHAM AL.

RECORD # 145 ASE 6/86,18
05-01-86 CITY OF TUCSON TUCSON
HAS EQUIPPED 5 OF ITS BUS SHELTERS WITH PV AS PART OF A PILOT PROGRAM. AN ADDITIONAL 330 BUS SHELTERS WILL BE EQUIPPED IN THE NEXT 6 YEARS. EACH SHELTER USE A 40W SOLAREX MODULE.

RECORD # 124 PV INTER. 1/86,18
01-01-86 DAIMER-BENZ WEST GERMANY
IS IN THE PROCESS OF ACQUIRING MAJOR CONTROL OF AEG CORPORATION.

RECORD # 127 RENEW 1/86,1
01-01-86 DEPARTMENT OF DEFENSE WASHINGTON DC
THE DOD IS THE WORLDS LARGEST USER OF ENERGY AND SOON WILL BE COME A HIGH VOLUME BUYER OF PV SYSTEMS.

RECORD # 164 SOLAR AGE 4/86,20
04-01-86 DINH
HAS INVENTED A SUN TRACKER THAT IS POWERED AND CONTROLLED BY PV.

RECORD # 170 PVIR 6/86,3
05-01-86 DINH
INTRODUCED A PV WELL PUMP SERIES CALLED SERIES 900. IT A STAND-ALONE SYSTEM THAT INCLUDES 3, 46 W MODULES, 4 STORAGE BATTERIES, AND A PUMP. THE COST IS $2399.

RECORD # 139 ASE 12/85,43
01-01-86 DYNAMOTE CORP. SEATTLE
HAS A NEW LINE OF UXB SINE WAVE STATIC INVERTERS. THE INVERTERS USE FIELD EFFECT TRANSISTORS.

PV EVENTS 1985-86

RECORD # 73 SEIR 04/86,142
04-06-86 ECD
HAVE SIGNED A MEMORANDUM OF UNDERSTANDING WITH INDIAN INVESTO RS . PARTNER IN THE JOINT VENTURE IS SOVONICS. NEW VENTURE CA LLED SURYONICS AND WILL ESTABLISH A 5 MW/YR. PV PLANT.

RECORD # 167 PVIR 6/86,1
05-01-86 ECD TROY
HAS SIGNED A MEMORANDUM OF UNDERSTANDING THAT COULD LEAD TO BUILDING A 5 MW PV MANUFACTURING PLANT IN INDIA.

RECORD # 92 PVNEWS 6/86,5
06-01-86 ECD
HAS SIGNED A MEMORANDUM OF UNDERSTANDING WITH SOVONICS AND IN DIAN INVESTORS TO BUILD ESTABLISH AN INDIAN COMPANY TO BUILD AND SELL PV PRODUCTS IN INDIA.

RECORD # 165 SOLAR AGE 6/86,45
06-01-86 ECD
STANDARD OIL OF OHIO IS WITHDRAWING AS A PV PARTNER WITH ECD. SOHIO HAS INVESTED MORE THAN $85 MILLION INTO THE PV EFFORTS .

RECORD # 90 PVNEWS 6/86,4
06-01-86 ENEA ITALY
FORMING A NEW LABORATORY TO STUDY A-SI CELLS. THEY WILL HIRE 100 PROFESSIONALS TO STUDY A-SI.

RECORD # 40 SEIR 12/85,431
12-23-85 ENERGY CONVERSION DEVICES TROY
HAVE AGREED TO A BUSINESS RELATIONSHIP WITH CANON INC. TOKYO JAPAN .

RECORD # 101 PVNEWS 5/86,4
05-01-86 ENERGY MATERIALS CORP. SOUTH LANCASTER
BEGINNING TO SHIP SILICON BLANKS THAT ARE MADE FROM THEIR LOW ANGLE SILICON SHEET PROCESS.

PV EVENTS 1985-86

RECORD # 23 WSM 11/85,5
11-01-85 EUREKA
PRODUCTION OF A-SI FOR PV WAS ONE OF 10 SPECIFIC PROGRAMS BY 18 EUROPEAN COUNTRIES INVOLVED IN EUREKA.

RECORD # 171 PVIR 6/86,3
05-01-86 HELIOTROPIC GENERAL SPRING VALLEY
INTRODUCED POLE MOUNTING HARDWARE FOR ARCO 5W A-SI GENESIS MODULE.

RECORD # 95 PVNEWS 6/86,7
06-01-86 HOXAN CORP. JAPAN
HAS SHIPPED ITS FIRST PV MODULES MANUFACTURED FROM SPIN-CAST SILICON. THE CELLS HAS EFFICIENCIES OF 11.5 TO 12%.

RECORD # 120 PV INTER. 1/86,16
01-01-86 INTEGRATED POWER CORP.
NAMED GETTYS-EAD-ADAIR INC. AS ITS REPRESENTATIVE FOR ITS PV AND PV/HYBRID POWER GENERATORS THAT IT WILL BE SELLING TO THE OIL INDUSTRY.

RECORD # 70 SEIR U4/86,121
04-15-86 INTEGRATED POWER CORP. ROCKVILLE
HAS COMPLETED THE CONSTRUCTION OF 2 MOBILE PV GENERATORS FOR THE NAVY. EACH TRAILER HAS A 2.4 KW PV ARRAY.

RECORD # 100 PVNEWS 5/86,4
05-01-86 INTERGRATED POWER CORP. ROCKVILLE
HAS SUCCESSFULLY COMPLETED BUILDING 2, 2.4 KW MOBILE SOLAR ELECTRIC GENERATORS. THE TRAILER-MOUNTED SYSTEMS WILL BE USED TO POWER REMOTE TELECOMMUNICATIONS EQUIPMENT.

RECORD # 159 PV INTERNL 5/86,28
05-01-86 INTERSOL
VIRGINIA ELECTRIC AND POWER CO. SELECTED THE INTERSOL 2 AXIS TRACKERS FOR ITS PV TEST FACILITY. THEY ARE COMPARING THE POWER GENERATING CAPABILITIES OF FIXED, SINGLE AND 2 AXIS SYSTEM

PV EVENTS 1985-86

RECORD # 163 SOLAR AGE 2/86,40
02-01-86 ISOFOTON SPAIN
IS INTRODUCING ITS PV PRODUCTS IN THE US. THEY WILL OFFER 25, 50 AND 100 WATT MODULES, PRICED AT ABOUT $7.50/WATT. THEY PRODUCED ABOUT 200 KW OF PV MODULES IN 1985.

RECORD # 130 ASE 1/86,42
01-01-86 JADE MOUNTAIN IMPORT/EXPO REDWOOD VALLEY
IS THE NEW NAME AND ADDRESS OF REAL GOODS TRADING COMPANY.

RECORD # 30 SEIR 11/85, 393
11-25-85 JOHNSON CONTROLS INC. MILWAUKEE
HAS DEMONSTRATED A HYDROGEN/NI OXIDE BATTERY THAT IS AS RELIABLE AFTER 7000 CYCLES AS AFTER THE FIRST. THE PRICE OF THE BATTERY IS CURRENTLY TOO HIGH FOR MOST APPLICATIONS.

RECORD # 81 SEIR 05/86,166
05-27-86 KANSAI POWER UTILITIES KOBE CITY JAPAN
WILL BUILD A 200 KW PV GENERATING FACILITY USING 100 2 KW STATIONS. THE CONSTRUCTION BEGAN IN APRIL AND WILL BE COMPLETED IN JANUARY 1987.

RECORD # 52 SEIR 02/86,38
02-04-86 KYOCERA SAN DIEGO
HAS INCREASED ITS WARRENTEE TO 10 YEARS ON ITS COMPLETE LINE OF POWER MODULES. THEY EXPECT THEIR MODULES TO OPERATE WELL FOR AT LEAST 20 YEARS.

RECORD # 113 PVNEWS 3/86,4
03-01-86 KYOCERA SAN DIEGO
HAS EXTENDED ITS WARRENTEE ON THEIR ENTIRE LINE OF PV MODULES FROM 5 TO 10 YEARS. THEY WILL REPLACE ANY MODULE THAT DOES NOT PRODUCE 90% OF ITS RATED OUTPUT DUE TO DEFECTS IN MATERIAL

RECORD # 64 SEIR 03/86,99
03-25-86 KYOCERA TOKYO, JAPAN
WILL BEGIN PRODUCING ITS OWN POLYCRYSTALLINE FOR ITS PV CELLS . THEY USE TO BUY THE MATERIAL FROM WACKER. WILL INCREASE PV SHIPMENTS TO 4 MW/YR.

PV EVENTS 1985-86

RECORD # 149 ASE 6/86,28
05-01-86 KYOCERA SAN DIEGO
HAS EXTENDED ITS WARRANTY ON ITS PV MODULES FROM 5 TO 10 YEARS. THEY EXPECT THEIR MODULES OF PERFORM SATISFACTORILY FOR 20 YEARS.

RECORD # 161 PV INTERNL 5/86,29
05-01-86 KYOCERA SAN DIEGO
HAS ANNOUNCED A NEW 10 YEAR WARRANTY ON ITS LINE OF PV MODULES. IF ANY MODULE FAILS TO PRODUCE 90% OF ITS RATED CAPACITY, KYOCERA WILL REPLACE IT.

RECORD # 22 WSM 11/85,5
11-01-85 MACDONNELL DOUGLAS
WILL JOIN IN THE DEVELOPMENT OF THIN FILM PV WITH AN EXISTING CO.

RECORD # 26 RENEW 10/85,8
11-01-85 MASS. ELECTRIC COMPANY GARDNER
WORKERS ARE COMPLETING 4.4 KW CITY HALL PV SYSTEM AND WILL BEGIN ON 5, 2-KW RESIDENTIAL SYSTEMS.

RECORD # 128 ASE 1/86,41
01-01-86 MASSACHUSETTS ELECTRIC GARDNER
HAS STARTED A $1 MILLION TO INSTALL RESIDENTIAL AND COMMERCIAL PV SYSTEMS. 30 WILL BE RESIDENTIAL AND 5 WILL BE COMMERCIAL. MOBIL SOLAR IS THE PRIME CONTRACTOR.

RECORD # 115 PVNEWS 3/86,5
03-01-86 MATSUSHITA JAPAN
HAS STARTED MASS PRODUCTION OF SCREEN-PRINTED THIN FILM CELLS CALLED SUNCERAM II. TEXAS INSTRUMENTS HAS ADOPTED THE CELL FOR THEIR POCKET CALCULATORS.

RECORD # 25 RENEW 10/85,8
11-01-85 MERIDIAN CORP. FALLS CHURCH
PV WATER PUMPING IS RELIABLE AND LIKELY TO COMPETE WITH DIESEL SYSTEMS FOR LOW FLOW OF LOW HEAD APPLICATIONS.

PV EVENTS 1985-86

RECORD # 66 SEIR 03/86,99
03-25-86 MIYAKEN JAPAN
IS OFFERING A PV PANEL FOR RECHARGING A CAR BATTERY. THE CHAR GER PRODUCES 17.5 VOLTS AND 34 MILLI AMPS AND IT PLUGS INTO A CIGARETTE LIGHTER.

RECORD # 137 ASE 12/85,42
01-01-86 MOBIL SOLAR CORP. WALTHAM
HAS INSTALLED THE FIRST UTILITY INTERACTIVE BILLBOARD IN THE US. THE UNIT IS POWERED BY 64 OF MOBIL'S 30 WATT MODULES. ELE CTRICITY IS USED TO POWER LIGHTS AND A TEMPERATURE.

RECORD # 79 SEIR 05/86,162
05-20-86 MOBIL SOLAR CORP. WALTHAM
HAS SIGNED A CONTRACT WITH NARRAGANSETT ELECTRIC CO. TO PROVI DE PV SYSTEMS AT 3 RHODE ISLAND LOCATIONS. THE FIRST TWO SYST EMS WILL FEATURE MOBIL SOLAR'S 220 WP MODULES.

RECORD # 143 SOLAR AGE 9/85,77
09-01-85 MOBIL SOLAR CORP. WALTHAM
OFFERS TWO PV LIGHTING KITS FOR REMOTE LOCATIONS. BLUE RIBBON 1 HAS 30 WATT MODULE, 15 WATT FLUORESCENT LIGHT. KIT TWO HAS TWO PANELS AND LIGHTS.

RECORD # 10 SE&C 11/85,11
11-01-85 MOBIL SOLAR ENERGY CORP. WALTHAM
WILL RPOVIDE MODULES FOR THE MASS. ELECTRIC CO. PV COMMUNITY PROJECT IN GARDNER. INVOLVE INSTALLING 86KWP ON 30 RES. AND 5 COMMERCIAL/INDUSTRIAL.

RECORD # 62 SEIR 03/86,89
03-18-86 MSEPG SAN DIEGO
SIGNED A LETTER OF INTENT TO PROVIDE ITS PV GENERATORS FOR A PROJECT IN THE MIDDLE EAST. WILL PROVIDE POWER TO SEVERAL SKY SCRAPPERS.

RECORD # 96 PVNEWS 5/86,2
05-01-86 MSETEK CO. MORGAN HILL
MAKES AND SELLS SINGLE CRYSTAL SILICON CELLS AND MODULES OF 4 1 WATTS. IN 1986 MSETEK US WAS FORMED TO CELL PV CELLS. THEY CURRENTLY PROVIDE CELLS TO ARCO SOLAR.

PV EVENTS 1985-86

RECORD #	45	SEIR 01/86,17
01-14-86	NASA LEWIS	CLEVELAND

A TELECONFERENCING CENTER WAS SET-UP IN WAWOTOBI TO LINK THE VARIOUS UNIVERSITY CENTERS. THE INDONESIAN COMMUNICATIONS SATELLITE PALAPA IS BEING USED TO LINK THE CAMPUSES.

RECORD #	109	PVNEWS 4/86,5
04-01-86	NEDO	JAPAN

HAS COMPLETED A 1 MW PLANT AT SAIJO THAT WILL BE OPERATED BY SHIKOKU ELECTRIC POWER COMPANY.

RECORD #	17	WSM 10/85,8
10-01-85	OSAKA UNIVERSITY	OSAKA

DEVELOPED THE BASIC TECHNOLOGY FOR A WET SOLAR CELL.

RECORD #	7	SE&C 11/85,7
11-01-85	PHOTOCOMM INC.	SCOTTSDALE

HAS ACQUIRED THREE PV DISTRIBUTORS: ELECTRASUN TUCSON AZ, SOLAR PRODUCTS PRESCOTT AZ, AND INDEPENDENT POWER NORTH SAN JUAN CA.

RECORD #	136	ASE 12/85,39
01-01-86	POLYCRYSTALLINE SILICON	MESA

IS SELLING MINI POLY SILICON PLANTS. THEY OFFER TWO VERSIONS: A 1 MT/YEAR AND A 3 MT/YR.

RECORD #	20	WSM 11/85,3
11-01-85	PRAGMA	

COMPLETED A MAJOR EXPANSION OF THEIR PRODUCTION FACILITY IN NETTUNO TO 2 MW. 1985 PRODUCTION WAS 500 KW AND 1986 IS ESTIMATED TO BE 1 MWP.

RECORD #	21	WSM 11/85,3
11-01-85	PRAGMA	

ABOUT 55% OF THEIR ANNUAL PRODUCTION IS EXPORTED TO EGYPT, IRAQ, AND SAUDI ARABIA. ABOUT 40% OF THEIR MODULES ARE FOR CATHODIC PROTECTION.

PV EVENTS 1985-86

RECORD #	31	PVNEWS 11/85,2	
11-01-85	PVIEA	DENVER	
HAS STARTED THE PV INFORMATION AND EDUCATION ASSOCIATION.			
RECORD #	65	SEIR 03/86,99	
03-25-86	SAB NIFE	SWEDEN	
HAS PRODUCED A BATTERY TO MATCH THE CHARACTERISTICS OF PV SYSTEMS. THE NICKEL CADMIUM BATTERY HAS A PREDICTED LIFETIME OF 20 YEARS.			
RECORD #	108	PVNEWS 4/86,5	
04-01-86	SANYO	JAPAN	
DEVELOPED A LOW POWER COLOR TV POWERED BY A 50-WATT A-SI PANEL.			
RECORD #	51	SEIR 02/86,37	
02-04-86	SANYO ELECTRIC COMPANY	SUMOTO CITY JAPAN	
IS MOVING TOWARDS THE MANUFACTURE OF A-SI CELLS FOR POWER GENERATING. SANYO HAS BEEN PRODUCING A-SI CELLS FOR POCKET CALCULATORS AT A PACE OF 3 MW PER YEAR. WILL PRODUCE 4.5 MW IN 19			
RECORD #	50	SEIR 02/86,37	
02-04-86	SEMICONDUCTOR ENERGY LABS	TOKYO JAPAN	
DEVELOPED AN A-SI CELL WITH A 9.9% CONVERSION EFFICIENCY. THE CELL IS CONSTRUCTED ON A GLASS SUBSTRATE, A-SI IS FORMED ON THE SUBSTRATE AND THE ELECTRODES ARE ATTACHED.			
RECORD #	82	SEIR 05/86,167	
05-27-86	SEMICONDUCTOR LABORATORY	TOKYO JAPAN	
HAS DEVELOPED A 9.9% EFFICIENT A-SI CELL WITHOUT USING AN ANTIREFLECTIVE COATING. WITH THE COATING THE EFFICIENCY INCREASES TO 10.2%.			
RECORD #	2	SEIR 10/85,362	GOLDEN
10-28-85	SERI	GOLDEN	
LAUNCHED A 3 YEAR COST SHARING PROGRAM TO STUDY A-SI. FUNDING OF UP TO $25 MILLION WILL BE MATCHED BY INDUSTRY.			

PV EVENTS 1985-86

RECORD # 3 SEIR 10/85,362 GOLDEN.
10-28-85 SERI GOLDEN
AWARDED ITS FIRST FIVE RESEARCH UNIVERSITY SUBCONTRACTS TO N. CAROLINA U, USC, U OF UTAH, BROWN U., AND STANFORD U.

RECORD # 34 PVNEWS 11/85,3
11-01-85 SERI
MANAGE THREE YEAR COST-SHARING EFFORT TO ADVANCE A-SI ON A CO OPERATIVE BASIS WITH INDUSTRY. UP TO $25 MILLION WILL BE SPEN T ON THE PROGRAM BETWEEN 1987-89.

RECORD # 28 RENEW 11/85,8
11-01-85 SOLAR ELECTRIC SYSTEMS ST PETERSBURG
IS FULFILLING A MILLION DOLLAR CONTRACT TO PROVIDE PV MODULES FOR 2600 REMOTE RADIO TELEPHONE UNITS BEING INSTALLED IN COL OMBIA, BOLIVIA, AND PARAGUAY.

RECORD # 5 SEIR 10/85,351
10-21-85 SOLAR LOBBY
THE SOLAR LOBBY MUST FIND NEW SOURCES OF INCOME SOON TO HELP REDUCE ITS 120K DEBT. ALTERNATIVE WOULD BE TO MERGE WITH ANOT HER ORGANIZATION.

RECORD # 122 PV INTER. 1/86,16
01-01-86 SOLAREX
ANNOUNCED THE OPENING OF A EUROPEAN SALES OFFICE IN MILAN ITA LY. THE OFFICE WILL HAVE RESPONSIBILITIES FOR EUROPE, THE MID DLE EAST, AND AFRICA.

RECORD # 123 PV INTER. 1/86,18
01-01-86 SOLAREX
ANNOUNCED THE DEVELOPMENT OF AN A-SI SUPERLATTICE CELL WITH A CONVERSION EFFICIENCY OF 10.4%.

RECORD # 116 PVNEWS 1/86,4
01-01-86 SOLAREX CORP. ROCKVILLE
IS INTRODUCING THEIR NEW SOLARSTATE CHARGE CONTROLLER. IT CON TROLS THE FLOW OF CURRENT FROM A PV ARRAY INTO A STORAGE BATT ERY.

PV EVENTS 1985-86

RECORD # 42 SEIR 01/86,3
01-07-86 SOLAREX CORP.
WILL PROVIDE A 500 KW PV SYSTEM TO THE US POST OFFICE IN PUER TO RICO. IT IS A COMBINATION OF GRID INTERACTIVE AND STANDAL ONE PV. HAS A BATTERY BANK FOR BACKUP POWER REQUIREMENTS.

RECORD # 47 SEIR 01/86,23
01-21-86 SOLAREX CORP. ROCKVILLE
CORRECTION!!! SOLAREX WON A CONTRACT TO INSTALL A 50 KW (NOT A 500 KW) PV SYSTEM IN PUERTO RICO.

RECORD # 154 ASE 3/86,44
03-01-86 SOLAREX CORP. ROCKVILLE
HAS BENN AWARDED A CONTRACT TO SUPPLY 33 PV SYSTEMS TO POWER REPEATER STATIONS IN PERU.

RECORD # 155 ASE 3/86,44
03-01-86 SOLAREX CORP. ROCKVILLE
SIGNED A CONTRACT TO SUPPLY A 100 KW GRID INTERACTIVE SYSTEM FOR THE TOWN OF JUANA DIAZ PUERTO RICO.

RECORD # 105 PVNEWS 4/86,3
04-01-86 SOLAREX CORP. NORTH PALM BEACH
HAS ESTABLISHED A MARKETING CENTER FOR THE SOUTHEAST..

RECORD # 148 ASE 6/86,28
05-01-86 SOLAREX CORP. ROCKVILLE
HAS DEVELOPED A NEW A-SI SUPERLATTICE CELL WITH A 10.4% CONVE RSION EFFICIENCY.

RECORD # 152 ASE 6/86,28
05-01-86 SOLAREX CORP. ROCKVILLE
HAS A NEW A-SI MODULE THAT IT WILL BE SELLING TO OEMS. THE MO DULE IS RATED AT 5 WATTS.

RECORD # 76 SEIR 05/86,151
05-13-86 SOLAREX CORP. ROCKVILLE
HAS BEGUN MARKETING A-SI PLASMA DEPOSITION EQUIPMENT. THE UNI T IS NOT DESIGNED FOR MANUFACTURING OF PV BUT FOR R&D.

PV EVENTS 1985-86

RECORD #	83	SEIR 05/86,170	
05-27-86	SOLAREX CORP.	ROCKVILLE	
HAS SIGNED A CONTRACT WITH PHILADELPHIA ELECTRIC CO. TO INSTALL A 3.6 KW A-SI ARRAY AT THE LIMEROCK POTTSTOWN AIRPORT.			
RECORD #	93	PVNEWS 6/86,6	
06-01-86	SOLAREX CORP.	ROCKVILLE	
ESTABLISHED A CONTRACT WITH PHILADEPHIA POWER TO INSTALL A 3.6 KW ARRAY OF A-SI MODULESAT THE LIMEROCK-POTTSTOWN AIRPORT.			
RECORD #	129	ASE 1/86,42	
01-01-86	SOLEC INTERNATIONAL		
HAS BOUGHT PILKINGTON BROTHER'S INTEREST IN THE COMPANY.			
RECORD #	24	RENEW 10/85,8	
10-01-85	SOUTHERN COMPANY		
WILL BUILD A 1 MW PV PRODUCTION FACILITY IN BIRMINGHAM WITH THE AID OF CHRONAR CORP. PLANT WILL BE ONLINE IN 1986 AND EMPLOY ABOUT 100 PEOPLE.			
RECORD #	168	PVIR 6/86,1	
05-01-86	SOUTHERN METHODIST UNIVER	DALLAS	
FABRICATED A CD TE CELL WITH A 10.5% CONVERSION EFFICIENCY. FIRST TIME THAT A CD TE CELL HAS GONE OVER 10%.			
RECORD #	53	SEIR 02/86,40	
02-04-86	SOVIET UNION		
INVESTIGATING THE POSSIBILITY OF LAUNCHING A 500 MW PV GENERATING STATION INTO SPACE. THE UNIT WOULD REQUIRE 5 SQ. KM OF A-SI PV MODULES BUILT IN NEAR EARTH THEN LAUNCHED INTO ORBIT.			
RECORD #	133	ASE 1/86,42	
01-01-86	SOVONICS		
INTRODUCED THE LARGEST A-SI MODULE THAT IS RATED AT 50.6 WATTS.			
RECORD #	140	ASE 12/85,43	
01-01-86	SOVONICS	SOLON	
IS NOW MARKETING THEIR FIRST A-SI PV PRODUCT UNDER THE NAME SUNPAK. THE PANELS ARE FLEXIBLE, AND LIGHTWEIGHT. THEY ARE AVAILABLE IN 2,5, AND 10 WATT POWER RATINGS.			

PV EVENTS 1985-86

RECORD # 111 PVNEWS 3/86,2
03-01-86 SOVONICS TROY
HAS DEVELOPED A ROL TO ROLL MANUFACTURING PROCESS THAT ALLOWS CONTINUOUS PRODUCTION OF PV MODULES.

RECORD # 156 ASE 3/86,46
03-01-86 SOVONICS SOLON
ACHIEVED A CONVERSION EFFICIENCY OF 12.2% WITH AN A-SI CELL.

RECORD # 60 SEIR 03/86,86
03-18-86 SOVONICS SOLON
INTRODUCING THE FRONTIER 100 A THIN FILM FLEXIBLE PV MODULE RATED AT 32 WATTS PEAK. THE MODULE IS DESIGNED FOR REMOTE RESIDENTIAL AND COMMERCIAL ELECTRIC MARKETS.

RECORD # 106 PVNEWS 4/86,4
04-01-86 SOVONICS
HAS TERMINATED 25-30 PEOPLE AND REDUCED ITS OVERALL PV BUDGET FROM $22 MILLION IN 1985 TO $10 MILLION STARTING MARCH 1986. REASONS INCLUDE DECREASED OIL PROFITS, & NEW MANAGEMENT AT B

RECORD # 71 SEIR 04/86,109
04-08-86 SOVONICS TROY
STANDARD OIL CO. HAS TERMINATED TWO OF ITS PARTNERSHIPS WITH SOVONICS. ECD HAD RECENTLY LAID-OFF TWO DOZEN WORKERS.

RECORD # 99 PVNEWS 5/86,3
05-01-86 SOVONICS
SOHIO IS SELLING ITS 51 % INTEREST IN SOVONICS. SOHIO HAS INVESTED OVER $90 MILLION IN THE VENTURE. ABOUT 600,000 SHARES WILL BE SOLD FOR $30/SHARE.

RECORD # 150 ASE 6/86,28
05-01-86 SOVONICS SOLON
INTRODUCED ITS FRONTIER 100 FLEXIBLE PV MODULE RATED AT 32 WATTS. THE MODULE IS DESIGNED FOR REMOTE RESIDENTIAL AND COMMERCIAL ELECTRIC POWER MARKETS.

PV EVENTS 1985-86

RECORD #	12	SE&C 11/85,11
11-01-85	SOVONICS	TROY
SET RECORD CONVERSION EFFICIENCY OF 12.2% FOR A-SI CELL.		

RECORD #	36	SEIR 11/85,389
11-18-85	SOVONICS	
HAS COMMERCIALLY INTRODUCED ITS R100 A-SI POWER MODULE. ITS THE WORLD'S LARGEST A-SI POWER MODULE GENERATING 32 WATTS. MA IN USE IS TELECOMMUNICATIONS, IRRGATION & VILLAGE POWER.		

RECORD #	58	SEIR 03/86,73
03-04-86	SOVONICS SOLAR SYSTEMS	LEPE, SPAIN
PV IRRIGATION SYSTEM HAS BEEN INSTALLED FOR A STRAWBERRY FARM . USES 28, PANELS PRODUCING 896 WATTS.		

RECORD #	16	WSM 10/85,8
10-01-85	SOVONICS SOLAR SYSTEMS IN	SOLON
A TRIPLE STACKED PV CELL WAS TESTED AT 12.2% EFFICIENCY.		

RECORD #	121	PV INTER. 1/86,16
01-01-86	SOVONICS.	
ANNOUNCED A RECORD CONVERSION EFFICIENCY OF 13% ON FOR ITS A-SI CELLS. ACHIEVED ON A 1 SQUARE CENTIMETER CELL THAT HAS THREE LAYERS OF FLORINATED A-SI MATERIALS.		

RECORD #	135	ASE 12/85,39
01-01-86	SPIRE CORP.	BEDFORD
POLAROID HAS ASSUMED CONTROL OF SPIRE'S ADVANCED MULTIJUNCTION A-SI RESEARCH AND HAS MOVED THE RESEARCH FACILITIES TO BOSTON. WILL LEAD TO PILOT PLANT TO PRODUCE LARGE AREA A-SI.		

RECORD #	55	SEIR 02/86,55
02-18-86	SPIRE CORP.	
SIGNED A CONTRACT WITH RAJASTHAN ELECTRONICS TO DELIVER A TURNKEY PV PANEL PRODUCTION FACILITY.		

RECORD #	56	SEIR 02/86,55
02-18-86	SPIRE CORP.	
RECEIVED A $1.1 MILLION CONTRACT FROM SERI TO CONUCT RESEARCH ON A-SI MULTIJUNCTION CELLS.		

PV EVENTS 1985-86

RECORD # 112 PVNEWS 3/86,4
03-01-86 SPIRE CORP. BEDFORD
HAS RECENTLY SOLD THEIR PV PRODUCTION EQUIPMENT TO REIL OF IN DIA.

RECORD # 67 SEIR 03/86,99
03-25-86 SPIRE CORP.
ANNOUNCED ITS NEW DUAL CHAMBER MOCVD DEPOSITION SYSTEM.

RECORD # 74 SEIR 04/86,146
04-06-86 SPIRE CORP. BEDFORD
ABOUT 93% OF THEIR PV SALES IN 1985 WENT TO FORIEGN CUSTOMERS COMPARED TO 77% IN 1984. SPIRE'S EQUIPMENT IS NOW USED IN 18 COUNTRIES THROUGHOUT THE WORLD.

RECORD # 157 PV INTERNL 5/86,28
05-01-86 SPIRE CORP. BEDFORD
RECEIVED A $1.1 MILLION FROM SERI TO CONTINUE RESEARCH ON ADV ANCED MULTIJUNCTION A-SI CELLS. TRYING TO ACHIEVE A CONVERSIO N EFFICIENCY OF 13%.

RECORD # 169 PVIR 6/86,2
05-01-86 SPIRE CORP. BEDFORD
EARNED $1.3 MILLION ON SALES OF $13 MILLION FOR 1985. PREVIOU S YEAR SALES WERE $9 MILLION.

RECORD # 78 SEIR 05/86,154
05-13-86 SPIRE CORP.
HAS CONTRACTED WITH NASA TO INVESTIGATE SEVERAL CELL TECHNOLO GIES INCLUDING INP, GA AS MULTIBANDGAP CELLS.

RECORD # 84 SEIR 06/86,178
06-03-86 SPIRE CORP. BEDFORD
SET A RECORD MODULE EFFICIENCY OF 15.2% WITH A SILICON MODULE . THE WORK WAS PERFORMED WHILE UNDER CONTRACT TO THE US DEPAR TMENT OF ENERGY.

RECORD # 85 SEIR 06/86,192
06-17-86 SPIRE CORP. BEDFORD
RECEIVED A $116,000 AWARD FROM SANDIA NATIONAL LAB TO DEVELOP METALIZATION MATERIALS FOR GA AS AN AL GA AS CONCETRATOR PV CELLS.

PV EVENTS 1985-86

RECORD # 13 SE&C 11/85,11
11-01-85 SPIRE CORP. BEDFORD
RECEIVED $500,000 AWARD FROM DOE'S SMALL BUSINESS INNOVATIVE

RECORD # 14 SE&C 11/85,11
11-01-85 SPIRE CORP. BEDFORD
RECEIVED $500,000 AWARD FROM DOE'S SMALL BUSINESS INNOVATIVE RESEARCH PROGRAM TO STUDY SINGLE CRYSTLLINE SI.

RECORD # 37 SEIR 11/85,389 BEOFORD
11-18-85 SPIRE CORP. 8EDFORD
HAD SALES OF $3.3 MILLION FOR THE THIRD QUARTER OF 1985. TOTAL SALES FOR THE FIRST 9 MONTHS OF 1985 WERE $10.4 MILLION, UP BY 54% FROM THE PREVIOUS YEAR.

RECORD # 48 SEIR 01/86,30
01-28-86 SPRINGBORN LA8S ENFIELD
HAS ANNOUNCED THE AVAILA8ILITY OF ETHYLENE VINYL ACETATE FOR ENCAPSULATING PV CELLS LAMINATED IN MODULES. IT PROVIDES ELECTRICAL INSULATION TO THE CELLS.

RECORD # 27 RENEW 11/85,8
11-01-85 STANDARD ELECTRICA MADRID
100 KW PV PLANT HAS BEEN INSTALLED ONLINE IN SPAIN. THE COST OF THIS FACILITY IS 2.8 MILLION.

RECORO # 72 SEIR D4/86,126
04-22-86 STANFORD UNIVERSITY PALO ALTO
HIT A RECORD 27.5% CONVERSION EFFICIENCY WITH A SINGLE CRYSTAL PV CELL.

RECORD # 88 PVNEWS 6/86,3
06-01-86 STANFORD UNIVERSITY PALO ALTO
DEVELOPED A SILICON CELL WITH A CONVERSION EFFICIENCY OF 22.2 %. INCREASED THE THEORETICAL CELL EFFICIENCY IS NOW 27%.

RECORD # 63 SEIR 03/86,98
03-25-86 SUMITOMO ELECTRIC TOKYO, JAPAN
PREDICTS THAT WITHIN 3 YEARS THE COST OF PV WILL FALL TO $1.0 0/WP. TESTING A THIN FILM AND A-SI GERMANIUM CELL TO REDUCE PV COSTS.

PV EVENTS 1985-86

RECORD # 144 SOLAR AGE 1/86,106
01-01-86 SUNAMP SYSTEMS INC. SCOTTSDALE
SELLS COMPLETE WATER PUMPING SYSTEMS THAT INCLUDE: PUMP, PUMP HEAD, MOTOR, DROP PIPE, PV MODULES, MOUNTING RACKS, AND INSTRUCTIONS.

RECORD # 18 WSM 10/85,8
10-01-85 TAIYO YUDEN CO.
DEVELOPED A METHOD FOR MASS-PRODUCING FLEXIBLE GLASS SUBSTRATE A-SI SOLAR CELLS.

RECORD # 6 SEIR 10/85,351
10-21-85 THE SOUTHERN COMPANY ATLANTA
HAS CONTRACTED WITH CHRONAR TO PURCHASE A 1 MW A-SI MANUFACTURING PLANT. SOUTHERN WILL CONTRIBUTE $6.12 MM AND CHRONAR $1.08 MM.

RECORD # 118 PVNEWS 1/86,5
01-01-86 TRACE ENGINEERING ARLINGTON
DEVELOPED A LINE OF FET POWER INVERTERS RANGING FROM 12V THROUGH 48V AND 250 THROUGH 6000 WATTS.

RECORD # 89 PVNEWS 6/86,4
06-01-86 TVA KNOXVILLE
OPENED THE TVA'S PV TESTING FACILITY. SYSTEM INCLUDES 4, 4KW TEST HOUSES, A 10 KW 2-AXIS TRACKING SYSTEM, AND A 5.2 KW ENTECH CONCENTRATING SYSTEM. PV TEND TO MEET TVA'S PEAK LOADS.

RECORD # 166 SOLAR AGE 6/86,45
06-01-86 TVA
DEDICATED 6 PV SYSTEMS IN THE CHATTASNOOGA AREA. ABOUT 30 WATTS ARE INSTALLED ON ROOF TOPS OF 4 TEST HOMES.

RECORD # 49 SEIR 01/86,31
01-28-86 UNIVERSITY OF SOUTH WALES
HAS DEVELOPED A SILICON SOLAR CELL WITH A 20.9% CONVERSION EFFICIENCY. THE CELL USES A SERIES OF V-SHAPED MICROGROOVES CUT INTO THE DEVICE.

DATE LISTED 08-13-86

PV EVENTS 1985-86

RECORD # 33 PVNEWS 11/85,3
11-01-85 UTILITY POWER GROUP
A NEW COMPANY THAT SPECIALIZES IN THIN FILM SYSTEMS FOR ELECTRIC UTILITY APPLICATIONS. WIIL PRODUCE 1 KW SINGLE AXIS TRACKING UNITS USING A-SI.

RECORD # 8 SE&C 11/85,7
11-01-85 VARIAN ASSOC. PALO ALTO
REPORTED A CONVERSION EFFICIENCY OF MORE THAN 21% FOR GA AS.

RECORD # 104 PVNEWS 4/86,3
04-01-86 VARIAN ASSOCIATES
A VARIAN CONCENTRATOR (300X) MADE FROM GA AS AND IN GA HAD A 26.6% EFFICENCY.

RECORD # 43 SEIR 01/86,16
01-14-86 WATER PUMPING AUSTRALIA
A PV SYSTEM WITH A PASSIVE SOLAR TRACKER IS A CHEAPER POWER SOURCE FOR IRRIGATION SYSTEMS IN AUSTRALIA THAN A WINDMILL SYSTEM.

RECORD # 97 PVNEWS 5/86,3
05-01-86 WESTINGHOUSE
WITHIN THE LAST YEAR WESTINGHOUSE HAS MADE VAST IMPROVEMENTS IN THEIR DENDRITIC WEB PROCESS. MODULE EFFICIENCIES HAVE INCREASED TO BETWEEN 12.5 TO 13%.

RECORD # 68 SEIR 04/86,102
04-01-86 WESTINGHOUSE CORP. PITTSBURGH
HAS ANNOUNCED A $1 MILLION UPGRADE OF ITS PV MANUFACTURING LAB. THIS UPGRADE WILL INCREASE PRODUCTION 25 FOLD.

RECORD # 160 PV INTERNL 5/86,28
05-01-86 WESTINGHOUSE CORP.
IS UPGRADING ITS PV MANUFACTURING LABORATORY TO COME CLOSER TO A FULL FLEDGED PRODUCTION FACILITY.

RECORD # 110 PVNEWS 3/86,2
03-01-86 WORLD BANK BOLIVIA
IN AN AGREEMENT WITH THE DOE AND SANDIA HAS PRODUCED THREE WA
TER PUMPING SYSTEMS FOR USE IN REMOTE SITES IN BOLIVIA.

RECORD # 41 SEIR 01/86,2
01-07-86 YOFFE INSTITUTE LENINGRAD
DEVELOPED A CONCENTRATOR PV CELL THAT HAS A 27% EFFICIENCY. T
HE CELL IS CAPABLE OF HANDLING CONCENTRATIONS OF UP TO 1000 S
UNS.

RECORD # 151 ASE 6/86,28
05-01-86 ZOMEWORKS ALBUQUERQUE
HAS A NEW PASSIVE SOLAR TRACKER- MODEL 8624 FOR ARRAYS OF 15
TO 24 MODULES.

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