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Solar Collector Manufacturing Activity 1993

August 1994

**Energy Information Administration
Office of Coal, Nuclear, Electric and Alternate Fuels
U.S. Department of Energy
Washington, DC 20585**

MASTER

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Preface

The "Solar Collector Manufacturing Activity 1993" (SCMA 1993) report prepared by the Energy Information Administration (EIA) presents national and State-level data on the U.S. solar thermal collector and photovoltaic cell and module manufacturing industry. The data are reported to the EIA by U.S.-based manufacturers and importers of solar equipment on the Forms CE-63A, "Annual Solar Thermal Collector Manufacturers Survey," and CE-63B, "Annual Photovoltaic Module and Cell Manufacturers Survey."

Detailed information is presented on 1993 U.S. industry total shipments and shipments by market sector, end-use application, and destination. These data describe the status of the industry at the end of 1993. Historical data for comparison are presented for annual shipments of solar thermal collectors for the years 1974 through 1993 and of photovoltaic cells and modules for the years 1982 through 1993. Two new sections included in 1993 are entitled "Industry Developments" and "Legislation." Throughout the report, the unit of measure for solar thermal collectors is square feet of collector surface and for photovoltaic cells and modules is peak kilowatts.

Appendix A of the report describes the survey methodology. Appendix B contains the 1993 survey forms and instructions. Appendices C and D list the companies that responded to the 1993 CE-63A and CE-63B surveys and

also granted permission for their name and address to appear in the report. Appendix E provides selected tables from this report with data converted to the International System of Units (SI) metric units. Appendix F provides an estimate of installed capacity and energy production from solar collectors for 1993.

This report provides annual data necessary for the Department of Energy to execute its responsibilities to (1) monitor activities in the solar collector industry, (2) implement the National Energy Strategy, and (3) provide information on the development and status of the industry to the Congress, Federal and State government agencies, solar energy manufacturers and specialists, universities and research institutes, and the general public.

The EIA and its predecessor organizations began conducting voluntary telephone surveys of the solar thermal collector industry in 1975 to monitor manufacturing activities. The first survey collected data for 1974, and subsequent surveys were conducted semi-annually through 1981. Since 1982, the surveys have been conducted annually, except for 1985, when the Form CE-63A survey was not conducted. The collection of energy data on Forms CE-63A and CE-63B is mandated under the Federal Energy Administration Act of 1974, Section 13 (Public Law 93-275).

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Data Summary

Solar Thermal Collectors

Solar thermal collector shipments totaled 7.0 million square feet in 1993 compared with 7.1 million square feet in 1992. A 3-percent decrease in shipments of low-temperature collectors, used primarily to heat residential swimming pools, was responsible for this decline. Shipments of low-temperature collectors decreased in 1993 to 6.0 million square feet from 6.2 million square feet in 1992. Shipments of medium-temperature collectors remained relatively unchanged at 0.9 million square feet in 1993 (Figure H1). The number of companies that shipped solar thermal collectors declined from 45 in 1992 to 41 in 1993.

The total value of solar thermal collector shipments in 1993 was \$27.6 million, a 9-percent increase from 1992. This growth was due to a rise in the average price per square foot of both low- and medium-temperature collectors. The average price of low-temperature collectors rose 12 percent to \$2.79 per square foot in 1993, while the average price of medium-temperature collectors rose 7 percent to \$11.73 per square foot.

At the end of 1993, 30 States had legislation providing some financial incentives for investment in the use of solar thermal collectors and photovoltaic (PV) modules and cells, compared with 27 States in 1992. Montana, North Dakota, and South Dakota approved financial incentives during 1993. The legislative actions were passed to encourage the use of an environmentally clean source of energy, to promote energy conservation through the use of renewable energy technologies, and to promote energy efficiency. Among the most common incentives were property tax exemptions and income tax credits for both the residential and business sectors.

California, New York, New Jersey, Florida, and Puerto Rico accounted for 98 percent of the total shipments of solar thermal collectors in 1993. California continued to

Figure H1. Solar Thermal Collector Shipments by Collector Type, 1981-1993

Note: Data for 1985 are incomplete and are not shown.

Sources: 1981-1984: Energy Information Administration, Form EIA-63, "Annual Solar Thermal Collector Manufacturers Survey." 1985-1993: Energy Information Administration, Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey."

be the top shipping State, accounting for 42 percent of total solar thermal collector shipments in 1993. The top five domestic destinations for shipments were Florida, California, Arizona, Hawaii, and Puerto Rico. Together, Florida and California received 80 percent of all domestic shipments.

Photovoltaic Cells

Shipments of photovoltaic (PV) cells and modules (Figure H2) totaled 21.0 peak megawatts in 1993, an increase of 34 percent above the 1992 level. The total value of PV cell and module shipments in 1993 was \$110 million, 26 percent higher than in 1992.

PV exports rose to 14.8 peak megawatts in 1993, a record level, and an increase of 51 percent from 1992 exports. Since 1988, PV exports have exceeded domestic shipments, increasing at an average annual rate of 23 percent. In 1993, exports accounted for 71 percent of total PV shipments.

After declining 61 percent between 1990 and 1992, PV shipments to the commercial sector increased 72 percent in 1993. PV shipments to the residential sector rose 144 percent between 1990 and 1992 and continued to rise in 1993 by 26 percent. The average price of crystalline silicon cells increased 59 percent in 1993 due to customer demand for custom cell orders for specific end-use products. Without the custom cell orders, the average price of PV crystalline silicon cells would have been somewhat lower but still above the 1992 average. The average price for crystalline silicon modules declined from \$6.10 per peak watt in 1992 to \$5.11 per peak watt in 1993, a 16 percent drop.

Figure H2. Domestic and Export Shipments of Photovoltaic Cells and Modules, 1985-1993

Note: Domestic Shipments equal total shipments minus exports.

Source: Energy Information Administration, Form CE-63B, "Annual Photovoltaic Cell/Module Manufacturers Survey."

The Energy Information Administration estimates that solar thermal collectors and PV modules and cells provided approximately 0.07 quadrillion Btu of energy production in the United States during 1993 (see Appendix F).

Industry Developments

Breakthrough in Solar Industry

The Department of Energy announced on January 18, 1994, that a 3-year government/industry partnership has produced a new thin-film solar technology that can supply all the daytime power needed for a home at almost half the present cost.¹ The new photovoltaic (PV) solar panels will be manufactured at a new plant site by United Solar Systems Corporation in Newport News, Virginia.

The new thin-film solar panel technology can be made into roofing shingles that could supply daytime electric power needs of a south-facing residential home. This new technology is expected to reduce the cost for PV electricity from 25 to 50 cents per kilowatthour to 12 to 16 cents per kilowatthour.

Photovoltaic Manufacturing Technology

The Photovoltaic Manufacturing Technology (PVMaT) project is an historic government/industry partnership for carrying out research and development (R&D) in the area of photovoltaic (PV) manufacturing. PVMaT consists of joint activities between the U.S. Department of Energy (DOE) and members of the U.S. PV industry.² The project's ultimate goal is to ensure that the U.S. industry not only retain but extend its world leadership role in manufacturing and commercial development of PV components and systems. PVMaT, a five-year, three-phase program, is designed to reduce PV manufacturing costs and expand the U.S. production capacity. PVMaT was started in early 1990, and the total DOE funding is expected to be approximately \$55 million with a similar amount cost shared by industry.

¹"Energy Department Announces Breakthrough in Solar Technology," *Department of Energy News*, U.S. Department of Energy (Washington, DC, R-94-003).

²"Four Firms To Negotiate with DOE On Manufacturing Technology Contracts," *The Solar Letter* (Washington, DC, September 3, 1993), p. 182.

Phase 1 PVMaT was completed in early 1991. There were 22 companies in Phase 1, with each company receiving \$35,000 to \$50,000. Phase 2 of PVMaT, which began in 1992, is expected to continue for 5 years. In Phase 2A, six contracts totalling \$46.2 million, and in Phase 2B, four contracts totalling \$40.1 million, were awarded. In Phase 3A, two contracts totalling \$2.9 million have been awarded.

New Sacramento Photovoltaic Power Station

The Sacramento Municipal Utility District (SMUD) began operation of a new, low cost PV power station in May 1994. The 200-kilowatt solar generating station at SMUD's Hedge substation is the lowest cost utility-scale sun tracking PV system ever built, constructed at a cost reported by the utility to be 20 percent lower than costs of previous utility PV systems. SMUD attributed the lower costs largely to the simplified design of the solar station's support structure and tracking equipment, which is constructed out of utility poles rather than traditional steel and concrete.

Built next to a primary substation, the Hedge Solar Station is an example of "peak shaving," a new concept where utilities use alternative energy sources to boost output during peak summer periods. PVs fit this need because on hot summer days, when energy use is at its highest, PVs are producing the most power.

The Hedge Solar Station is part of SMUD's Solar Program, considered one of the leading utility-run solar programs in the country. Along with PV1 & 2, the world's largest utility-owned PV plant, SMUD operates 108 rooftop PV systems built on customers' homes, and during 1994, an additional 100 PV "mini-power plants" will be installed. The SMUD program also includes solar water heaters, passive solar design, and commercial air conditioners as well as participation in Solar Two, the solar thermal power demonstration project near Barstow, California.³

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³"California Utility Begins Operations At New Photovoltaic Power Station," *International Solar Energy Intelligence Report* (Washington, DC, May 30, 1994), p. 89.

Utility Photovoltaic Application Survey

More than 1,850 cost-effective PV systems with a total installed capacity of more than 87-peak kilowatts are owned and operated by 74 electric utilities throughout the United States, according to the survey results released in October 1993 by Electric Power Research Institute (EPRI), Palo Alto, California.

Investor-owned utilities own the greatest number of cost-effective systems (more than 1,500), followed by municipal utilities (more than 170), Federal- or State-owned utilities (more than 100) and rural electric cooperatives (more than 80). In the late 1970's, the utilities started installing the cost-effective PV devices, all of which to date serve small, isolated loads and have a size range of a few peak watts to more than 7-peak kilowatts.

EPRI rates the reliability of these stand-alone PV devices as very high. Some 97 percent of the utilities, with PV systems installed, reported that they were either satisfied or very satisfied with PV system performance. Over 37 percent of the utilities had experienced no downtime with their systems.

The survey identified several applications of PV technology in use by electric utilities today. These systems reduce a utility's cost and provide a low-risk means to develop a valuable experience base with PV and expand the understanding of the technology.⁴

Photovoltaic BONUS Program

In 1993 the DOE initiated several public/private cost-shared partnerships to commercialize renewable energy technologies. Their initiatives began as part of the Building Opportunities in the United States for PV programs (PV BONUS) and include the following solar program initiatives:

- A \$40 million, five-year program cost-shared with industry to develop solar cells that do

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⁴"Photovoltaics Cost-Effective for Utilities in Dozens of Applications: EPRI," *The Solar Letter* (Washington, DC, October 15, 1993), p. 203.

double duty as building components. Five proposals were accepted for negotiation.

- A \$40 million cooperative agreement between DOE and a consortium led by Southern California Edison to convert the 10-megawatt, central receiver, water-steam Solar One facility at Daggett, California, into Solar Two. This facility will use molten salt in the receiver and as the storage mechanism to enable electricity to be generated when the sun is not shining, resulting in the world's most advanced central receiver plant.
- A collaborative effort between DOE, the Edison Electric Institute, and the American Public Power Association to provide technical assistance to utilities to develop solar water heating programs as part of their services to customers.⁵

DOE Solar Power Task Force

The Department of Energy has named the members of the Solar Power Task Force for the Nevada Test Site (NTS). The task force is charged with exploring ways to use NTS for a solar-power generating and research facility featuring solar thermal electric and photovoltaic power plants.

The task force will be cochaired by Assistant Secretary for Energy Efficiency and Renewable Energy, Christine Ervin, and Senator Richard Bryan (D-Nev.). Other members are Nevada Gov. Bob Miller (D); DOE Nevada Operations Office Manager, Nick Aquilina; Pioneer Citizens Savings Bank President and CEO, Bill Martin; Nevada State Senator Dina Titus; Nevada AFL-CIO representative, Claude Evans; and Solar Energy Industries Association Executive Director, Scott Sklar.

An amendment to the 1992 Defense Authorization Bill directed DOE to conduct a feasibility study on the potential for solar power at NTS. The nuclear weapons test site, no longer needed for its original purpose, has

some of the best insolation in the country.⁶ The feasibility study, contracted by DOE, concluded that the 1,350-square-mile site could host an array of solar-electricity-generating equipment owned by private companies. The study suggested that private industry might be attracted to the site if the federal government provided the land, some power line improvements and other support. Less than 7 percent of the area would support 10,000 megawatts of solar electric generating capacity, 5 times the generating capacity of the Hoover Dam.

Low-Income Solar Program

On May 3, 1994, the DOE announced a pilot project to put solar water heaters on the rooftops of 1,000 low-income households in Florida during the next three years. The pilot effort, called the Solar Weatherization Assistance Program (SWAP), will have a budget of \$2.3 million, including \$800,000 from DOE and \$1.5 million from Florida's oil overcharge funds. The initial installations will target low-income households in Citrus, Pinellas, and Suwannee Counties.

The benefits, including the impact on family water heating bills, will be measured as part of the pilot project. Three to five types of systems will be tested for costs, including installation and maintenance.

The Florida Solar Energy Center, which has been involved in solar equipment standards and testing for 15 years, will provide training and technical support for the weatherization crews. The equipment will meet the center's certification requirements.

During the first phase of the pilot program, 150 solar water heaters will be installed by the end of the summer 1994, many of them by the Metropolitan Dade Community Action Agency in the Miami area.⁷

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⁵"DOE Announces New Public/Private Partnerships In Renewable Energy Research and Development," *DOE News*, U.S. Department of Energy (Washington, DC, April 29, 1994), R-94-074.

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⁶"Solar Power Task Force Named for Nevada Test Site," *DOE News*, U.S. Department of Energy (Washington, DC, April 29, 1994), R-94-074.

⁷"Low-Income Florida Residents to Benefit from Solar Power," *DOE News*, U.S. Department of Energy (Washington, DC, May 3, 1994), R-94-075.

Solar Energy Museum

On April 22, 1993, the Solar Energy Research and Education Foundation dedicated the Center for Renewable Energy and Sustainable Technology (CREST). The Center, which is located on Capitol Hill in Washington, DC, is a unique, new museum highlighting solar energy. A rooftop PV panel powers lights and computers running touch-control, visitor-interactive informational software, and a rooftop, solar-thermal system provides hot water.

CREST will feature interactive displays, examples of several renewable energy sources, including PV, solar thermal, wind, geothermal, hydropower, and biomass, and a unique, rotating "solar orb" created by Southern California Edison Co., for the 1993 Tournament of Roses Parade, that used 127 state-of-the-art PV cells to power the rotational motor. CREST eventually will also serve as a training center for designers, engineers and users interested in harnessing solar and other forms of renewable energy.⁸

Mobil Terminates Solar Programs

Mobil Corporation announced on November 4, 1993, the termination of its 19-year PV production operations program at Billerica, Massachusetts.⁹ Mobil's Chairman and Chief Executive, Allen E. Murray, said current PV technology "does not provide an adequate business opportunity either now or the foreseeable future." The Mobil Energy Solar Corporation is being actively sold on the market: it will maintain and support its proprietary technology.

Mobil's departure leaves only one American PV firm owned by an oil company, Solarex Corporation, Frederick, Md., a wholly owned subsidiary of Amoco Technology Corporation. Previous oil-company dropouts from the U.S. PV industry include Atlantic Richfield, Exxon Corporation, and Shell Oil Co.

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⁸"Unique Renewable Energy Museum Dedicated on Prominent DC Corner," *The SolarLetter*, (Washington, DC, April 30, 1993), p. 88.

⁹"Industry News," *Solar Industry Journal* (Washington, DC, Fourth Quarter, 1993).

Delmarva Power and Light Photovoltaic System Evaluation

On July 16, 1993, Delmarva Power and Light Company of Delaware installed a 15-kilowatt PV system at its Northern Division General Offices in Christiania, Delaware.¹⁰ The system was designed to provide electricity to commercial buildings in the area. An array of 40 PV modules is connected to the Delmarva grid through a two-way inverter. The Delmarva Power PV system gathers energy throughout the daylight hours. The energy is first used to charge storage batteries each morning and provide electricity to the building's occupants. As the utility's demand for power rises in the afternoon, the stored energy is combined with the PV production and is sent on to the utility's grid to reduce the peak demand for electricity on the utility system.

By displacing electricity on the customer's side of the meter, PV systems can allow facility owners to offset electricity normally required from the utility and reduce monthly demand charges. Billed demand charges reflect the peak amount of electricity required from a utility. Development of the PV system initiative for commercial application will be partially funded by the Department of Energy's PV: Bonus Program.

Rooftop Photovoltaics (PV) Program

The Environmental Protection Agency (EPA) is managing a two-phase program to collect field measurements of energy savings and air pollution reductions through rooftop PV systems.¹¹

Under Phase I begun in 1992, 16 PV systems (eight 4-kilowatt, one 8-kilowatt, and seven 12-kilowatt) were installed on residential and commercial rooftops in 11 U.S. cities. In Phase II, 11 additional systems focused on commercial, institutional, and light-industry buildings

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¹⁰Chris Whiteley, "Delmarva Power Demonstrates PV on Corporate Office Building," *Solar Industry Journal* (Washington, DC, 1993), p. 14.

¹¹"How Many Rooftop PV Systems Does it Take to Save the Planet?," *Solar Industry Journal*, by Ed Kem (Ascension Technology), and Anne Polansky (Solar Energy Industry Association) (Washington, DC, Fourth Quarter, 1993).

will be installed. The EPA and 11 electric utilities are sharing Phase I project costs of \$1.1 million on a 50/50 basis. In Phase II, 11 utilities, 9 new ones and 2 participating in Phase I, will sponsor installation and monitoring of 18-kilowatt systems to achieve a total capacity of 198 kilowatts. The Electric Power Research Institute is coordinating input of electric utility partners that, collectively, are providing 65 percent of the \$2.5-million total cost of Phase II.

Low-Cost Solar Power System

The Department of Energy's Sandia National Laboratories and Science Applications International Corporation are developing a 25-kilowatt solar thermal power system for commercial use.¹² The goal of this task is to develop and demonstrate a distributed power system suitable for commercial sale by the year 2000. The system is based on a stretched, faceted, membrane dish, developed by Sandia, and a 25-kilowatt solar dish, developed by Stirling Thermal Motors, Inc.

Siemens Solar Training Center

Siemens Solar Industries Inc., of Camarillo, California, has established a fully dedicated PV-powered international, solar-electric-technology and system-design training center.¹³ The 1,200-square-foot facility, which opened in the fall of 1993, includes a classroom and a hands-on laboratory where domestic and international customers receive training in "PV Technology and System Design," a course which has been given at Siemens Solar Industries for the past 11 years.

Legislation

Federal

Energy Policy Act of 1992 (P.L. 102-486)

The National Energy Policy Act (EPACT) of 1992, enacted on October 24, 1992, contains several provisions supporting a broader, more favorable treatment of solar energy. Major sections of EPACT affecting the solar industry are listed below:

- (a) Section 1202 created a 5-year cost-share energy efficiency and renewable energy plan including technology demonstration and commercial application programs which authorized expenditure of \$50 million in fiscal year (FY) 1994.
- (b) Section 1916 extended indefinitely, retroactive to June 30, 1992, the 10-percent investment tax credit for solar equipment. Commercial entities investing in or purchasing qualified solar energy property can take the credit on up to 10 percent of the investment or purchase price and installation amount. Solar energy property that qualifies for the credit includes:
  - Equipment that uses solar energy to generate electricity, including storage devices, power conditioning equipment, transfer equipment and related parts, and equipment up to (but not including) the stage that transmits or uses electricity.
  - "Dual use equipment" (equipment that uses both solar and non-solar energy, such as pipes and hot water tanks) only if its use of energy from non-solar sources does not exceed 25% of its total energy input in an annual measuring period, and only to the extent of its basis or cost allocation to its use of solar energy.

¹²"Industry News: Contracts and Installations," *Solar Industry Journal* (Washington, DC, Fourth Quarter, 1994), p. 8.

¹³"Siemens Sets up PV-Powered International Training Center," *The Solar Letter* (Washington, DC, January 7, 1994), p. 2.

Energy and Water Development Appropriations Act (P.L. 103-126)

On October 28, 1993, Congress passed a fiscal year (FY) 1994 appropriation for energy and water development that included DOE's Renewable Energy R&D program. In the solar energy area it included \$5 million for the Solar Buildings Program (up from \$3 million in FY 1993), \$78 million for the Photovoltaic Program (a 20-percent increase above the FY 1993 level of \$65 million), and \$33 million for the Solar Thermal Program (a 21-percent increase from the FY 1993 level of \$27 million).

Rural Electrification Loan Restructuring Act of 1993 (P.L. 103-129)

The Rural Electrification Loan Restructuring Act of 1993 was enacted on November 1, 1993. The Act contains a provision allowing rural electric cooperatives to make low interest (5 to 7 percent) loans to Rural Electric Cooperatives to assist them in "implementing demand side management, energy conservation programs, and on-grid and off-grid renewable energy systems." Previously, only energy systems that were used in central power applications were eligible for such loans.

State

In 1993, Montana, North Dakota, and South Dakota passed legislation providing for some financial incentives for investment in the use of solar thermal collectors and photovoltaic cells/modules. At the end of 1993, 30 States had legislation providing such financial incentives. These States are: Arizona, California, Connecticut, Hawaii, Idaho, Illinois, Indiana, Iowa, Kansas, Louisiana, Maine, Massachusetts, Maryland, Minnesota, Montana, Nevada, New Hampshire, New Jersey, New York, North Carolina, North Dakota, Ohio, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Dakota, Texas, Utah, and Virginia.

This 7.5-kilowatt dish-engine system developed and manufactured by Cummins Power Generation, Inc. of Columbus, Indiana, provides power for water pumping in Abilene, Texas.

Solar Thermal Collector Manufacturing Activities

This chapter presents information on the statistics of the solar thermal collector manufacturing industry in 1993. Solar thermal collector shipments, origins and destinations, imports, exports, collector types, values and prices, end uses, and market sectors are presented. Data on solar thermal collector shipments include both imported collectors and collectors manufactured by U.S.-based companies that were shipped for domestic use and for export.

Industry Status

In 1993, 41 companies were active in the solar thermal collector manufacturing industry. They shipped collectors totaling approximately 7.0 million square feet during the year (Table 1). Of the 41 companies active

in 1993, 5 were planning to introduce new low-temperature collectors, 11 were planning new medium-temperature collectors, and 4 were planning to introduce new high-temperature collectors in 1994 (Table 2).

From 1984 to 1986, the number of manufacturing companies declined by 127 (Table 1). At the end of 1985, the 40-percent residential energy tax credit and the 15-percent business energy tax credit expired. The decline in industry companies intensified with the drop in oil prices in 1986. The reinstatement of the business energy tax credit at the 15-percent level for 1986, at the 12-percent level for 1987 through 1991, and at the 10-percent level in 1992, plus increasing oil prices after 1986 appear to have had little effect on drawing companies into manufacturing solar thermal collectors.

Table 1. Number of Companies and Annual Shipments of Solar Thermal Collectors, 1974-1993
(Thousand Square Feet)

Year	Number of Companies	Solar Thermal Collector Shipments		
		Total	Import	Export
1974	45	1,274	NA	NA
1975	131	3,743	NA	NA
1976	186	5,801	NA	NA
1977	321	10,312	NA	NA
1978	340	10,860	396	840
1979	349	14,251	290	855
1980 ^a	233	19,398	235	1,115
1981 ^a	203	20,133	196	771
1982 ^a	265	18,621	418	455
1983 ^a	203	16,828	511	159
1984	225	17,191	621	348
1985	NA	NA	NA	NA
1986	98	9,360	473	224
1987	59	7,269	691	182
1988	51	8,174	814	158
1989	44	11,482	1,233	461
1990	51	11,409	1,562	245
1991	48	6,574	1,543	332
1992	45	7,086	1,650	316
1993	41	6,968	2,039	411

^aIncludes imputation of shipment data to account for nonrespondent.

NA = Not available. The data reported for 1985 are incomplete.

Note: Total shipments as reported by respondents include all domestic and export shipments and may include imported collectors that subsequently were shipped to domestic or foreign customers.

Sources: 1974-1977 : Federal Energy Administration telephone survey. 1978-1984: Energy Information Administration, Form EIA-63, "Annual Solar Thermal Collector and Photovoltaic Module Manufacturers Survey." 1985-1993: Energy Information Administration, Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey."

Table 2. Number of Companies Expecting to Introduce New Solar Thermal Collector Products in 1994

New Product Type	Number of Companies
Low-Temperature Collectors	5
Medium-Temperature Collectors . .	11
High-Temperature Collectors	4
Noncollector Components	7

Source: Energy Information Administration, Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey" (1993).

The Energy Policy Act of 1992, Section 1916, extends the 10-percent business tax credits for solar equipment indefinitely, retroactive to June 30, 1992. Investors in or purchasers of qualified solar energy property can take the credit on up to 10 percent of the investment or purchase price and installation amount. Section 1914 established a 1.5-cent per kilowatthour electricity production incentive for qualifying facilities.

At the end of 1993, 30 States provided financial incentives for investment in the use of solar thermal collectors and photovoltaic modules and cells, compared with 27 States in 1992 and 15 States in 1991. Montana, North Dakota, and South Dakota approved financial incentives during 1993. The legislative actions were passed to encourage the use of an environmentally clean source of energy, to promote energy conservation through the use of renewable energy technologies, and to promote energy efficiency. Among the most common incentives were property tax exemptions and income tax credits for both the residential and business sectors.

Since 1987, the 10 largest U.S. companies that shipped solar thermal collectors have supplied not less than 95 percent of all solar thermal collectors manufactured in or imported into the United States (Table 3). In 1993, 96 percent of the approximately 7.0 million square feet of total shipments were supplied by the 10 largest companies. In the period 1982 to 1984, the average share of the 10 largest companies was 50 percent of total shipments.

Table 3. Percent of Solar Collector Shipments by the Ten Largest Companies, 1982-1993

Year	Company Rank	Shipments (thousand square feet)	Percent of Total Shipments
1982 ...	1-5	6,320	34
	6-10	2,560	14
	1-10	8,880	48
1983 ...	1-5	5,919	35
	6-10	2,752	16
	1-10	8,671	52
1984 ...	1-5	6,092	35
	6-10	2,605	15
	1-10	8,697	51
1985 ...	NA	NA	NA
1986 ...	1-5	7,771	83
	6-10	785	8
	1-10	8,556	91
1987 ...	1-5	6,371	88
	6-10	499	7
	1-10	6,870	95
1988 ...	1-5	7,585	93
	6-10	335	4
	1-10	7,920	97
1989 ...	1-5	9,748	85
	6-10	1,321	12
	1-10	11,069	96
1990 ...	1-5	9,955	87
	6-10	1,029	9
	1-10	10,983	96
1991 ...	1-5	5,429	83
	6-10	829	13
	1-10	6,258	95
1992 ...	1-5	6,110	86
	6-10	609	9
	1-10	6,718	95
1993 ...	1-5	6,135	88
	6-10	551	8
	1-10	6,686	96

NA=Not available. The data reported for 1985 are incomplete. Note: Totals may not equal sum of components due to independent rounding.

Sources: 1982-1984: Energy Information Administration, Form EIA-63, "Annual Solar Thermal Collector and Photovoltaic Module Manufacturers Survey." 1985-1993: Energy Information Administration, Form CE-63A, "Annual Solar Thermal Manufacturers Survey."

In 1993 employment in solar-thermal-related activities decreased from 449 person-years to 392 person-years, a 13 percent drop from the 1992 employment level. Industry employment data for 1990 through 1993 are shown in the following table.

Year	Person Years Expended
1990	850
1991	338
1992	449
1993	392

Most of the 41 reporting companies in 1993 combined manufacturing and related activities with importing of solar thermal collectors:

- A total of 31 companies were involved in design of collectors or systems, 18 were developing prototype collectors, and 16 were developing prototype systems (Table 4).
- There were 24 wholesale companies and 24 retail companies. Of the 41 companies, 20 offered installation of their collectors.

Solar-related sales represented 90 to 100 percent of total company sales for 25 companies in 1993 versus 27 companies in 1992 (Table 5). Solar-related sales made up less than 10 percent of total sales for two companies in 1993, compared with four companies in 1992.

Shipments

Solar thermal collector shipments totaled approximately 7.0 million square feet in 1993, a 2-percent decrease from the 1992 level of approximately 7.1 million square feet (Table 1). Import shipments totaled 2.0 million square feet and export shipments were 0.4 million square feet in 1993 (Figure 1). Shipments of low-temperature solar thermal collectors decreased 3 percent to 6.0 million square feet in 1993 from 6.2 million square feet in 1992 (Table 6). Shipments of medium-temperature collectors in-

creased 4 percent to 0.93 million square feet in 1993 from 0.90 million square feet in 1992. Shipments of high-temperature collectors increased from 2,000 square feet in 1992 to 12,000 square feet in 1993.

Table 4. Number of Companies Involved in Solar-Thermal Activities by Type, 1992 and 1993

Type of Activity	Number of Companies	
	1992	1993
Collector or System Design	35	31
Prototype Collector Development	18	18
Prototype System Development	20	16
Wholesale Distribution	24	25
Retail Distribution	24	22
Installation	20	21
Noncollector System Component Manufacture	16	18

Source: Energy Information Administration, Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey."

Table 5. Solar-Related Sales as a Percentage of Total Sales, 1992 and 1993

Solar-Related Sales as a Percent of Total Sales	Number of Companies	
	1992	1993
90-100	27	25
50-89	7	9
10-49	7	5
Less than 10	4	2
Total	45	41

Source: Energy Information Administration, Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey."

Figure 1. Imports and Exports of Solar Thermal Collectors, 1978-1993

Note: Data for 1985 are incomplete.

Sources: 1978-1984: Energy Information Administration, Form EIA-63, "Annual Solar Thermal Collector and Photovoltaic Module Manufacturers Survey." 1985-1993: Energy Information Administration, Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey."

Origins

U.S. manufacturers in California, New York, New Jersey, Florida, and Puerto Rico produced 98 percent of U.S.-manufactured collectors in 1993, the same as in 1992. California continued to lead the Nation in 1993 with 42 percent of total domestic shipments. Shipments of U.S.-manufactured solar thermal collectors in 1993, which totaled 4.9 million square feet, originated from 17 States and Puerto Rico. California shipped 42 percent of U.S.-manufactured solar thermal collectors in 1993 compared with 55 percent in 1992 (Table 7). New York, New Jersey, and Puerto Rico shipped a combined 2.6 million square feet in 1993.

Distribution

Of total shipments in 1993, 53 percent were sent directly to wholesale distributors and 35 percent were sent to retail distributors (Table 8). Of export ship-

Table 6. Solar Thermal Collector Shipments by Type, 1980-1993
(Thousand Square Feet)

Year	Low-Temperature		Medium-Temperature		High-Temperature ^a
	Shipments	Average Annual Shipments per Manufacturer	Shipments	Average Annual Shipments per Manufacturer	Shipments
1980 ^b	12,233	155	7,165	29	NA
1981 ^b	8,677	116	11,456	436	NA
1982 ^b	7,476	123	11,145	45	NA
1983 ^b	4,853	88	11,975	67	NA
1984	4,479	93	11,939	58	773
1985	NA	NA	NA	NA	NA
1986	3,751	171	1,111	13	4,498
1987	3,157	263	957	19	3,155
1988	3,326	416	732	16	4,116
1989	4,283	428	1,989	55	5,209
1990	3,645	304	2,527	62	5,237
1991	5,585	349	989	24	1
1992	6,187	387	897	26	2
1993	6,025	464	931	28	12

^aFor high-temperature collectors, average annual shipments per manufacturer are not disclosed.

^bIncludes shipment data imputed for nonrespondents.

NA = Not available. The data reported for 1985 are incomplete.

Sources: 1980-1984: Energy Information Administration, Form EIA-63, "Annual Solar Thermal Collector and Photovoltaic Module Manufacturers Survey." 1985-1993: Energy Information Administration, Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey."

Table 7. Shipments by the Top 5 Solar Thermal Collector Manufacturing States/ Territories 1992 and 1993
(Thousand Square Feet)

Origin	Shipments ^a		Percent	
	1992	1993	1992	1993
California	2,985	2,074	55	42
Florida	208	194	4	4
Other ^b	2,146	2,563	39	52
Subtotal	5,339	4,831	98	98
Total U.S.	5,436	4,929	100	100

^aIncludes domestic shipments and exports.

^bOther includes New Jersey, New York, and Puerto Rico.

Notes: •Totals may not equal sum of components due to independent rounding. •Total U.S. represents only shipments manufactured in the United States.

Source: Energy Information Administration, Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey."

ments, 83 percent were sent directly to exporters. Direct shipments to installers, end users, and others accounted for 7 percent of total shipments in 1993.

Table 8. Distribution of Solar Thermal Collector Shipments, 1992 and 1993

Recipient	Shipments (thousand square feet)	
	1992	1993
Wholesale Distributors ..	3,537	3,710
Retail Distributors	2,709	2,410
Exporters	280	343
Installers	192	313
End Users and Other ^a ...	367	191
Total	7,086	6,968

^aOther includes minimal shipments not explained on Form CE-63A.

Note: Totals may not equal sum of components due to independent rounding.

Source: Energy Information Administration, Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey."

Collector Types

Solar thermal collectors are divided into the categories of low-, medium-, and high-temperature collectors. Low-temperature collectors provide heat up to 110° Fahrenheit through either metallic or nonmetallic absorbers and are used in applications such as swimming pool heating. Medium-temperature collectors provide heat greater than 110° Fahrenheit (usually 140 to 180° Fahrenheit) through either glazed flat-plate collectors that use air or liquid as the heat transfer medium or concentrator collectors that concentrate the heat of incident insolation to greater than "one sun." Medium-temperature collectors are used for water, space, and process heating. Evacuated-tube collectors are included in this category. High-temperature collectors are parabolic dish and trough collectors and are used primarily by utilities and nonutility power producers in the generation of electricity for the grid. A high-temperature solar thermal collector operates at temperatures above 180 degrees Fahrenheit.

Between 1980 and 1984, annual low-temperature collector shipments decreased from 12.2 million to 4.5 million square feet (Figure 2). From 1986 through 1993, annual shipments of low-temperature collectors ranged between 3.2 and 6.2 million square feet.

In 1983 and 1984, before the expiration of the energy tax credits at the end of 1985, medium-temperature collector manufacturers shipped just under 12 million square feet each year. By the end of 1986, shipments declined to 1.1 million square feet. In 1990, shipments of medium-temperature collectors were 2.6 million square feet, and from 1991 through 1993 shipments have been below 1 million square feet each year.

Low-temperature collectors dominated the solar thermal industry in 1993, accounting for 86 percent of total shipments (Table 9). Medium-temperature collectors accounted for 13 percent of total collector shipments in 1993. Flat plate collectors represented 9 percent of total shipments.

Collectors that constituted subunits of thermosiphon systems or integral collector storage systems (ICS) represented 4 percent of total shipments (Table 9). High-temperature collectors, shipped primarily for

Figure 2. Shipments of Low- and Medium-Temperature Solar Thermal Collectors, 1980-1993

Note: Data for 1985 are incomplete.

Sources: 1985-1993: Energy Information Administration, Form EIA-63, "Annual Solar Thermal Collector and Photovoltaic Module Manufacturers Survey." 1985-1993: Energy Information Administration, Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey."

research and demonstration projects, represented less than one percent of total shipments in 1993.

Values and Prices

The total value of solar thermal collector shipments was \$27.6 million in 1993; a 9-percent increase compared with 1992 (Table 9). The average price of low-temperature collectors increased to \$2.79 from \$2.49 (dollars per square foot), and the average price of ICS and thermosiphon collectors increased to \$14.62 in 1993 from \$12.64 in 1992. This increase was due primarily to increased material costs. The average price for flat-plate collectors in 1993 increased to \$9.44 from the corresponding 1992 level of \$9.32 per square foot (Figure 3). The value of shipments includes charges for advertising and warranties. Excluded are excise taxes and the cost of freight or transportation for the shipments.

Table 9. Solar Thermal Collector Shipments by Type, Quantity, Value, and Average Price, 1992 and 1993

Type	1992			1993		
	Quantity (thousand square feet)	Value (thousand dollars)	Average Price (dollars per square foot)	Quantity (thousand square feet)	Value (thousand dollars)	Average Price (dollars per square foot)
Low-Temperature						
Liquid and Air	6,187	15,403	2.49	6,025	16,819	2.79
Medium-Temperature						
Air	1	8	11.57	1	7	10.19
Liquid						
ICS/Thermosiphon	303	3,825	12.64	304	4,446	14.62
Flat Plate	584	5,441	9.32	623	5,887	9.44
Evacuated Tube	W	W	W	2	174	82.19
Concentrator	W	W	W	1	9	14.40
All Medium Temperature	897	9,831	10.96	931	10,523	11.31
High-Temperature						
Parabolic Dish and Trough	2	148	75.66	12	260	22.11
Total	7,086	25,382	--	6,968	27,602	3.96

W = Data withheld to avoid disclosure.

ICS = Integral collector storage.

-- Not applicable.

Note: Totals may not equal sum of components due to independent rounding.

Source: Energy Information Administration, Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey."

Figure 3. Average Price of Solar Thermal Collectors, 1992 and 1993

Source: Energy Information Administration, Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey."

Markets

In 1993, the residential sector was the largest market for solar thermal collectors. Solar thermal collectors shipped to the residential sector in 1993 totaled 6.7 million square feet, 96 percent of total shipments (Table 10). This market sector primarily involves the use of low-temperature solar collectors for heating swimming pools and medium-temperature collectors for water heating in residential buildings. The resi-

dential sector was also the largest market in 1992. The second largest market for solar thermal collectors in 1993 was the commercial sector, which accounted for 3 percent of total shipments.

Uses

The largest end use for solar thermal collectors shipped in 1993 was for heating swimming pools, and it represented 87 percent of the total square feet shipped (Table 11). This application usually involved the use of low-temperature collectors. A common low-temperature pool-heating solar collector is a black plastic or rubber-like sheet with tubing through which water is circulated. The heat of the sun is transferred directly from the black absorbing material to the water circulating through the tubing to supply heat to the pool. Shipments for pool heating declined 3 percent in 1993 from the level reported in 1992.

The second largest end use in 1993 was for domestic hot water systems, which accounted for 13 percent of the total square feet shipped. Typical solar water-heating systems feature flat-plate collectors or collectors installed in an ICS or thermosiphon system. Unlike pool-heating systems, domestic solar water-heating systems nearly always have a conventional backup (i.e., gas or electric). Shipments in 1993 for hot water systems increased 10 percent from the 1992 level.

Table 10. Shipments of Solar Thermal Collectors by Market and Type, 1992 and 1993
(Thousand Square Feet)

Market Sector	Low-Temperature	Medium-Temperature					High-Temperature	1993 Total	1992 Total
	Liquid/Air	Air	Liquid			Parabolic Dish/Trough			
	Metallic and Nonmetallic		ICS/Thermosiphon	Flat-Plate (Pumped)	Evacuated Tube		Concentrator		
Residential	5,841	1	297	552	2	1	1	6,694	6,832
Commercial	171	0	3	41	0	0	0	215	204
Industrial	14	0	2	15	0	0	0	31	27
Utility	0	0	2	15	(^S)	0	11	28	17
Other ^a	0	0	(^S)	0	0	0	(^S)	1	6
Total	6,025	1	304	623	2	1	12	6,968	7,086

^aOther includes shipments of solar thermal collectors to other sectors such as government, including the military but excluding space applications.

(^S) = Less than 500 square feet.

ICS = Integral Collector Storage.

Note: Totals may not equal sum of components due to independent rounding.

Source: Energy Information Administration, Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey."

Table 11. Shipments of Solar Thermal Collectors by End Use and Type, 1992 and 1993
(Thousand Square Feet)

End Use	Low-Temperature	Medium-Temperature					High-Temperature	1993 Total	1992 Total
	Liquid/Air	Air	Liquid			Parabolic Dish/Trough			
	Metallic and Nonmetallic		ICS/Thermosiphon	Flat-Plate (Pumped)	Evacuated Tube		Concentrator		
Pool Heating	6,011	0	0	29	0	0	0	6,040	6,210
Hot Water	0	0	302	575	2	1	1	880	801
Space Heating	14	1	(^S)	0	0	0	0	15	35
Space Cooling	0	0	0	0	0	0	0	0	1
Combined Space and Water Heating	0	0	0	4	0	0	0	4	5
Process Heating	0	0	2	15	0	0	0	17	32
Electricity Generation	0	0	0	0	0	0	11	11	1
Other ^a	0	0	0	0	0	(^S)	0	(^S)	1
Total	6,025	1	304	623	2	1	12	6,968	7,086

^aOther includes shipments of solar thermal collectors for other uses such as cooking foods, water pumping, water purification, desalinization, distilling, etc.

(^S) = Less than 500 square feet.

ICS = Integral Collector Storage.

Note: Totals may not equal sum of components due to independent rounding.

Source: Energy Information Administration, Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey."

Medium-temperature collectors also were shipped for space heating, and for installation into systems that provide both space and water heating and process heating. High-temperature parabolic dish and trough collectors were shipped for electricity generation and hot water in 1993.

Destinations

Domestic

Solar thermal collectors were shipped to 41 States, Puerto Rico, and the U.S. Virgin Islands in 1993. In 1992, 42 States received collector shipments (Table 12). The four States and one U.S. territory that received the largest amounts of solar thermal collectors in 1993 were: Florida (56 percent), California (23 percent), Arizona and Puerto Rico (4 percent each), and Hawaii (3 percent) (Table 13). All of the collectors manufactured in Puerto Rico remained on the island. The U.S. market for solar thermal collectors continued to be highly concentrated in a few States and Puerto Rico. Factors favorable for solar energy

use that these States and Puerto Rico have in common are: (1) good solar insolation; (2) high electricity costs; (3) solar-promoting incentives, such as tax credits or exemptions; and (4) a demand for low technology solar pool heaters and solar domestic hot water systems.

Export

Exports accounted for 6 percent of total shipments in 1993. A total of 19 companies exported solar thermal collectors in 1993 compared with 16 companies in 1992. Of total 1993 exports, low-temperature collectors accounted for 24 percent and medium-temperature collectors 73 percent. Summed by continents, the largest percentage of shipments were to North America (32 percent), followed by Asia (28 percent) and Europe (23 percent) (Table 14). Trading countries that received export shipments were Taiwan (15 percent), Japan (10 percent), Australia (9 percent), Mexico (9 percent), Austria (8 percent), Canada (7 percent), and France (6 percent) (Table 14).

Table 12. Shipments of Solar Thermal Collectors by Destination, 1992 and 1993
(Square Feet)

Destination	Shipments		Destination	Shipments	
	1992	1993		1992	1993
Alabama	1,878	1,682	Nebraska	1,749	1,682
Alaska	0	0	<u>Nevada</u>	78,417	13,009
<u>Arizona</u>	209,731	285,506	<u>New Hampshire</u>	1,956	1,725
Arkansas	2,029	1,682	<u>New Jersey</u>	67,217	60,926
<u>California</u>	1,777,328	1,540,145	New Mexico	8,944	10,240
Colorado	44,667	23,611	<u>New York</u>	68,266	75,757
<u>Connecticut</u>	11,529	13,908	<u>North Carolina</u>	5,609	5,840
Delaware	0	0	<u>North Dakota</u>	0	0
District of Columbia	0	0	Ohio	11,529	13,908
Florida	3,805,357	3,701,116	<u>Oklahoma</u>	92	0
Georgia	27,849	34,505	<u>Oregon</u>	82,425	122,534
<u>Hawaii</u>	169,746	196,507	Pennsylvania	29,309	17,620
<u>Idaho</u>	93	222	Puerto Rico	202,589	253,379
<u>Illinois</u>	21,309	27,709	<u>Rhode Island</u>	4,864	0
<u>Indiana</u>	9,780	12,579	South Carolina	1,951	2,620
<u>Iowa</u>	126	256	<u>South Dakota</u>	0	0
Kansas	1,905	2,036	Tennessee	1,749	1,794
Kentucky	0	0	<u>Texas</u>	18,837	40,254
Louisiana	1,749	1,682	<u>Utah</u>	47	354
Maine	2,570	23,909	Vermont	1,949	1,832
Maryland	11,543	14,236	Virgin Islands (U.S.)	7,435	2,923
<u>Massachusetts</u>	12,098	12,494	Virginia	3,378	2,097
Michigan	47	3,382	Washington	30,413	12,859
<u>Minnesota</u>	9,087	1,059	West Virginia	161	165
Mississippi	0	0	<u>Wisconsin</u>	18,867	15,300
Missouri	1,749	3,374	Wyoming	0	0
<u>Montana</u>	0	111			
Shipments to United States/Territories				6,769,923	6,556,529
Exports				315,773	411,475
Total Shipments				7,085,696	6,968,004

Notes: •Underlined States sponsored incentives for solar thermal collector purchases during 1992 (Solar Energy Industries Association, *Solar Industry Journal*, First Quarter 1993, pp. 16-21). States in bold face type sponsored incentives during 1993. (Steve Kalland, Solar Energy Industries Association, personal communication to James Holihan, Energy Information Administration, Washington, D.C. June 1, 1994).

Source: Energy Information Administration, Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey."

Table 13. Shipments Ranked by Top Five Destinations, 1992 and 1993

State or Territory	1992 Shipments			1993 Shipments		
	Thousand Square Feet	Percent of U.S. Total	Rank	Thousand Square Feet	Percent of U.S. Total	Rank
Florida	3,805	56	1	3,701	56	1
California	1,777	26	2	1,540	23	2
Arizona	210	3	3	286	4	3
Puerto Rico	203	3	4	253	4	4
Hawaii	170	3	5	197	3	5
Top Five Total	6,165	91	--	5,977	91	--

-- = Not Applicable

Notes: •Totals may not equal sum of components due to independent rounding. •Percentages are based on the total shipped each year to the United States and Territories shown in Table 12. •U.S. total includes territories.

Source: Energy Information Administration, Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey."

Table 14. Distribution of Solar Thermal Collector Exports by Country Within Continent, 1993

Continent	Country	Percent of Exports
Africa	Total	3.4
	South Africa	2.9
	Other Africa	0.5
Asia	Total	28.2
	Japan	9.7
	Taiwan	14.6
	Other Asia	3.9
Australia	Total	9.1
	Australia	9.1
Europe	Total	22.9
	Austria	8.2
	France	5.8
	Spain	1.0
	Switzerland	2.1
	Other Europe	6.0
North America	Total	32.3
	Antigua	2.0
	Bahamas	2.7
	Bermuda	2.0
	Canada	6.7
	Costa Rica	0.7
	Haiti	1.9
	Jamaica	1.9
	Mexico	8.9
	Trinidad	1.9
	Other Central America	1.6
	Other North America	1.9
South America	Total	4.1
	Chile	2.4
	Colombia	0.7
	Other South America	0.9

Notes: Other represents shipments to countries not disaggregated by companies on Form CE-63A and may include shipments to enumerated countries. Totals may not equal sum of components due to independent rounding.

Source: Energy Information Administration, Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey."

Systems

Of the 41 companies reporting shipments of solar thermal collectors in 1993, 31 reported shipments of 18,809 complete solar thermal collector systems. This was an 18-percent increase compared with 1992 (Table 15). A complete system is a unit with a collector and all the necessary functional components, except for installation materials. Included are thermo-siphon systems, integral collector storage systems, packaged systems, and system kits. The 18,809 complete systems accounted for 3.0 million square feet of collectors, an increase of 8 percent in square feet shipped above the 1992 level. The total value for the systems shipped in 1993 was \$20.6 million, compared with \$19.4 million in 1992.

Table 15. Shipments of Complete Solar Thermal Collector Systems, 1992 and 1993

	1992	1993
Complete Collector Systems Shipped ^a	15,946	18,809
System Shipments (thousand square feet)	2,763	2,989
System Shipments (percent of total shipments)	39	43
Number of Companies	35	31
Value of Systems (thousand dollars)	19,390	20,631

^aA complete system is a unit with a collector and all the necessary functional components, except for installation materials.

Source: Energy Information Administration, Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey."

Photovoltaic Cell and Module Manufacturing Activities

This chapter presents information on the U.S. photovoltaic (PV) cell and module manufacturing industry in 1993. It covers the status of the industry, PV cell and module shipments (expressed in peak kilowatts), manufacturing origins, destinations, imports, exports, cell and module types, values and prices, end uses and markets. PV shipments data in this chapter include cells and modules manufactured by U.S. companies that were shipped for domestic use and for export as well as imported cells and modules.

A PV module is an integrated array of PV cells assembled into a panel. PV cells are the unencapsulated semiconductor components of the module. PV cells convert a portion of the solar energy into electric energy. Cells and modules manufactured and shipped for space and satellite applications are not covered in this report.

Industry Status

PV cell and module shipments totaled 21.0 peak megawatts in 1993 (Table 16). These shipments were reported by 19 companies. Three companies expect to introduce new crystalline-silicon module products, and six companies reported plans to introduce new thin-film products to the industry during 1994 (Table 17). Two companies reported plans to produce new PV concentrator products and five plan new non-module system components during 1994.

Employment in PV-related activities totaled 1,431 person-years in 1993 (Table 18), a decrease of 32 person-years from the 1992 level of employment. The average employment per company was 75 person-years in 1993, compared with 70 person-years in 1992.

Table 16. Number of Companies and Total Shipments of Photovoltaic Cells and Modules, 1982-1993 (Peak Kilowatts)

Year	Number of Companies	Photovoltaic Cell and Module Shipments		
		Total	Import	Export
1982	19	6,897	NA	NA
1983	18	12,620	NA	1,903
1984	23	9,912	NA	2,153
1985 ^a	15	5,769	285	1,670
1986 ^a	17	6,333	678	3,109
1987 ^a	17	6,850	921	3,821
1988 ^a	14	9,676	1,453	5,358
1989 ^a	17	12,825	826	7,363
1990 ^a	^b 19	^b 13,837	1,398	7,544
1991 ^a	23	14,939	2,059	8,905
1992 ^a	21	15,583	1,602	9,823
1993 ^a	19	20,951	1,767	14,814

^aDoes not include shipments of cells and modules for space/satellite applications.

^bIncludes imputed data for one nonrespondent, which exited the industry during 1990. See Appendix A for imputation method.

NA = Not available.

Note: Total shipments as reported by respondents includes all domestic and export shipments and may include imports that subsequently were shipped to domestic or to foreign customers.

Sources: 1982-1984: Energy Information Administration, Form EIA-63, "Annual Solar Thermal Collector and Photovoltaic Module Manufacturers Survey." 1985-1993: Energy Information Administration, Form CE-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey."

Table 17. Companies Expecting to Introduce New Photovoltaic Products in 1994

New Product Type	Number of Companies
Crystalline Silicon	
Single-Crystal Silicon Modules	3
Cast Silicon Modules	3
Ribbon Silicon Modules	1
Thin-Film	
Amorphous Silicon Modules	6
Other ^a	3
Concentrators	2
Nonmodule System Components	5

^aOther includes various different component materials used in thin film modules.

Source: Energy Information Administration, Form CE-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey" (1993).

Table 18. Employment in the Photovoltaic Manufacturing Industry, 1989-1993

Year	Number of Companies	Number of Person-Years
1990	19	1,622
1991	23	1,588
1992	21	1,463
1993	19	1,431

Source: Energy Information Administration, Form CE-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey."

Many companies that are engaged in the manufacture and/or importation of PV cells and modules reported on the 1993 survey that they also are involved in other PV-related activities. Fifteen companies were involved in module or system design, 13 were active in development of module prototypes, and 13 were active in development of PV system prototypes (Table 19). Fifteen companies were involved in wholesale sales and 10 companies in retail sales. Nine companies, two more than in 1992, installed PV cells or modules.

Shipments

Of the 21.0 peak megawatts in PV cell and module shipments in 1993, module shipments accounted for

14.9 peak megawatts and cell shipments accounted for 6.0 peak megawatts. Total PV shipments in 1993 increased 34 percent above the 1992 level. Total shipments have increased 263 percent since 1985 (Figure 4). Data for PV cells and modules for terrestrial use only (i.e., excluding space applications) have been reported each year since 1985.

Table 19. Number of Companies Involved in Photovoltaic-Related Activities, 1992 and 1993

Type of Activity	Number of Companies	
	1992	1993
Cell Manufacturing	13	10
Module or System Design	18	15
Prototype Module Development . .	15	13
Prototype Systems Development . .	12	13
Wholesale Distribution	14	15
Retail Distribution	9	10
Installation	7	9
Noncollector System Component Manufacture	6	10

Source: Energy Information Administration, Form CE-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey."

Figure 4. Photovoltaic Cell and Module Shipments, 1985-1993

Source: Energy Information Administration, Form CE-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey."

Imports

Seven companies reported import shipments of PV cells and modules in 1993 totaling 1.8 peak megawatts, or 8 percent of total shipments (Table 16). The predominant type of imported PV cells and modules was crystalline silicon. These imports originated in Australia, China, and Japan, with Japan accounting for most of the imported PV cells and modules.

Distribution

In 1993, PV cell and module shipments totaling 10.4 peak megawatts (49 percent of total shipments) were sent directly to wholesale distributors (Table 20). Installers and end users combined received 3.6 peak megawatts (17 percent of total shipments).

PV cell manufacturers shipped 5.3 peak megawatts (25 percent of total shipments) to other companies that manufacture (assemble) cells into PV modules.

Table 20. Distribution of Photovoltaic Cells and Modules, 1992 and 1993

Recipient	Shipments (peak kilowatts)	
	1992	1993
Wholesale Distributors	8,604	10,354
Retail Distributors	592	862
Exporters	591	151
Installers	1,148	1,278
End Users	1,008	2,295
Module Manufacturers	2,511	5,256
Other ^a	1,129	754
Total	15,583	20,951

^aOther includes categories not identified by reporting companies.

Note: Totals may not equal sum of components due to independent rounding.

Source: Energy Information Administration, Form CE-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey."

Figure 5. Photovoltaic Cell and Module Shipments by Type, 1991-1993

Source: Energy Information Administration, Form CE-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey."

Cell and Module Types

PV shipments are divided into three categories by product type: (1) crystalline silicon cells and modules (includes single-crystal, cast silicon, and ribbon silicon); (2) thin-film cells and modules (made from a number of layers of photosensitive materials such as amorphous silicon); (3) concentrator cells and modules (in which a lens is used to gather and converge sunlight onto the cell or module surface).

Crystalline silicon cells and modules continued to dominate the PV industry in 1993, accounting for 96 percent of total shipments (Table 21). In particular, single-crystal silicon shipments totaled 13.6 peak megawatts, an increase of 49 percent compared with corresponding 1992 shipments (Figure 5). Together, cast and ribbon silicon shipments totaled 6.6 peak megawatts in 1993, a 22-percent increase from the corresponding 1992 shipments.

From 1992 to 1993, thin-film shipments decreased 27 percent (Table 21). Thin-film shipments represented 4 percent of total shipments in 1993.

Table 21. Shipments by Type of Photovoltaic Cells and Modules, 1991-1993

Type	Shipments (peak kilowatts)			Percent of Total Shipments		
	1991	1992	1993	1991	1992	1993
Crystalline Silicon						
Single-Crystal	8,685	9,078	13,560	58	58	65
Cast and Ribbon	5,520	5,379	6,587	37	35	31
Subtotal	14,205	14,457	20,146	95	93	96
Thin-Film Silicon	723	1,075	782	5	7	4
Concentrator Silicon	12	40	21	(*)	(*)	(*)
Other ^a	0	11	2	0	(*)	(*)
Total	14,939	15,583	20,951	100	100	100

^aOther includes categories not identified by reporting companies.

(*)Represents less than 0.5, rounded to zero.

Note: •Data do not include shipments of cells and modules for space/satellite applications. •Totals may not equal sum of components due to independent rounding.

Source: Energy Information Administration, Form CE-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey."

Values and Prices

The total value of photovoltaic cell and module shipments was \$110 million in 1993, a 26-percent increase over the 1992 value of \$87 million (Table 22). The total value includes charges for advertising and

warranties but does not include excise taxes and the cost of freight or transportation for the shipments.

The total value of crystalline silicon (single-crystal, cast, and ribbon) shipments was \$102.5 million in 1993, a 28-percent increase compared with the corresponding 1992 value. The value of thin-film ship-

Table 22. Value and Average Price of Cells and Modules by Type, 1992 and 1993

Type	1992			1993		
	Value (thousand dollars)	Average Price (dollars per peak watt)		Value (thousand dollars)	Average Price (dollars per peak watt)	
		Modules	Cells		Modules	Cells
Crystalline Silicon						
Single-Crystal	47,621	6.14	3.12	63,277	4.41	5.02
Cast and Ribbon	32,339	6.04	4.23	39,216	6.00	5.15
Subtotal	79,960	6.10	3.16	102,493	5.11	5.03
Thin-Film Silicon	6,851	6.31	10.67	6,001	7.64	10.13
Concentrator Silicon	189	4.37	10.08	W	W	W
Other ^a	74	6.00	10.00	W	W	W
Total	87,074	6.11	3.21	109,797	5.24	5.23

^aOther includes categories not identified by reporting companies.

W = Withheld to avoid disclosure of individual company data.

Notes: •Data do not include shipments of cells and modules for space/satellite applications. •Totals may not equal sum of components due to independent rounding.

Source: Energy Information Administration, Form CE-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey."

ments in 1993 was \$6.0 million, 12 percent less than in 1992.

The average price of crystalline silicon modules in 1993 was \$5.11 per peak watt, a decrease of 16 percent from the 1992 price of \$6.10 (Figure 6). The average price for thin-film modules was \$7.64 per peak watt, 21 percent higher than the 1992 price.

Figure 6. Average Price of Photovoltaic Modules, 1991-1993

Source: Energy Information Administration, CE-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey."

Uses

The largest end-use application of PV cells and modules in 1993 was for electricity generation (combined grid-interactive and remote). This represented 33 percent of total shipments (Table 23). Of the 6.8 peak megawatts represented by this end use, 99 percent involved crystalline silicon cells and modules. Grid interactive and remote, i.e., stand-alone, power generation include applications for grid distribution and general remote uses, such as residential power and power for mobile homes.

The second largest PV end use in 1993 was in the transportation sector, which accounted for 4.2 peak megawatts. PV units to power fixed-based com-

munications equipment, such as mountain-top signal-repeater stations, totalled 3.8 peak megawatts, or 18 percent of total shipments. In 1992, communications was the second largest PV end-use application.

End uses related to water pumping and original equipment manufacturers accounted for 2.3 peak megawatts and 2.0 peak megawatts, respectively, in 1993 and involved primarily the use of crystalline silicon cells and modules.

Sales for consumer goods accounted for 0.9 peak megawatts in 1993, a decline of 63 percent from 1992. PV cells and modules used for health and medical purposes, such as those used to power refrigerators, medical equipment, and water purifiers, totaled 0.7 peak megawatts in 1993, a ninefold increase over the 1992 level. End uses reported as "Other" for 1993 totaled 0.07 peak megawatts, a decline of 86 percent from 1992.

Destinations

Domestic

The industrial sector was the largest market for PV cells and modules in 1993, accounting for 26 percent of total shipments (Table 24). In this market, PV cells and modules are used to produce power for industrial applications including grid and nongrid systems. In 1993, 99.5 percent were crystalline silicon and 0.5 percent were thin-film silicon cells and modules. The industrial sector also represented the largest market for PV shipments in 1992.

Use of cells and modules in grid-connected and remote (nongrid) PV systems to provide power for the residential sector was the second largest market for PV in 1993, and accounted for 25 percent of total shipments.

The commercial market was the third largest PV market, accounting for 20 percent of total shipments in 1993. These cells and modules were shipped to provide power for commercial establishments such as office buildings, retail establishments, private hospitals, and schools (publicly owned hospitals and schools are listed under the government sector). In

Table 23. Shipments of Photovoltaic Cells and Modules by End Use and Type, 1992 and 1993
(Peak Kilowatts)

End Use	Crystalline Silicon	Thin-Film Silicon	Concentrator Silicon	Other	1993 Total	1992 Total
Electricity Generation						
Grid Interactive	1,040	45	11	0	1,096	1,227
Remote	5,724	30	7	0	5,761	4,238
Communication	3,824	22	0	0	3,846	3,717
Consumer Goods	W	W	0	0	946	2,566
Transportation	3,949	288	1	0	4,238	1,602
Water Pumping	2,287	6	2	0	2,294	809
Cells/Modules to OEM ^a	1,753	270	0	0	2,023	828
Health	664	10	0	0	674	67
Other ^b	W	W	0	2	74	530
Total	20,146	782	21	2	20,951	15,583

^aOEM means original equipment manufacturers.

^bOther uses include shipments of photovoltaic cells and modules for other uses such as cooking food, desalinization, distilling, etc.

W = Data withheld to avoid disclosure.

Note: Totals may not equal sum of components due to independent rounding.

Source: Energy Information Administration, Form CE-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey."

Table 24. Shipments of Photovoltaic Cells and Modules by Market and Type, 1992 and 1993
(Peak Kilowatts)

Market Sector	Crystalline Silicon	Thin-Film Silicon	Concentrator Silicon	Other	1993 Total	1992 Total
Industrial	5,327	25	0	0	5,352	4,279
Residential	5,225	7	5	0	5,237	4,154
Commercial	3,834	266	14	0	4,115	2,386
Transportation	2,224	340	0	0	2,564	1,673
Utility	1,478	25	0	0	1,503	1,553
Government ^a	1,303	21	2	0	1,325	1,063
Other ^b	755	99	0	2	856	477
Total	20,146	782	21	2	20,951	15,583

^aIncludes Federal, State, and local governments, excluding military.

^bOther includes shipments that are manufactured for private contractors for research and development projects.

Note: Totals may not equal sum of components due to independent rounding.

Source: Energy Information Administration, Form CE-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey."

contrast, the commercial sector accounted for 15 percent of total shipments in 1992.

PV cells and modules for the transportation sector, which were used to produce power on boats, cars, and recreational vehicles and to power transportation support systems, amounted to 2.6 megawatts. The trans-

portation sector accounted for 12 percent of total shipments in 1993 compared with 11 percent in 1992.

Shipments to the utility sector, where cells and modules were used to produce power at utility-owned systems including central stations, decentralized systems, and experimental applications, amounted to 1.5

peak megawatts in 1993, a 3-percent decrease from the 1992 level.

Shipments of PV cells and modules used to produce power at installations of Federal, State, or local governments (excluding military) totaled 1.3 peak megawatts in 1993. This compares with 1.1 peak megawatts shipped to the government sector in 1992. The "Other" sector (Table 24) in 1993 consisted of 0.9 peak megawatts shipped to foreign governments and for specialty purposes.

Exports

Export shipments totaled 15 peak megawatts in 1993, an increase of 51 percent from the 1992 level (Table 16). Generally, export shipments since 1990 have paralleled total shipments because of the continued search for new PV markets outside the United States (Figure 4). A total of 17 companies reported exports of PV cells and modules in 1993, and exports accounted for 71 percent of total PV shipments. Of all types of cells and modules exported in 1993, 99 percent were crystalline silicon (Table 25). Destinations of PV exports by continent are shown in Table 26, and destinations by country are shown in Table 27.

Systems

Of the 25 companies that reported shipments of PV systems in 1993, 12 reported shipments of 447 complete photovoltaic systems, nearly double the number shipped in 1992 (Table 28). A complete photovoltaic system is defined as a power supply unit that satisfies all the power requirements of an application. Such a system is generally made up of one or more modules, a power conditioning unit to process the electricity into the form needed by the application, wires and other electrical connectors, and sometimes batteries for back-up power supply. Some complex, large-scale PV systems use concentrators to focus incident insolation onto small PV cells and tracking systems to track the sun. In this report, installation materials such as the support frame and concrete foundations are not considered as part of a system. The value of systems reported in Table 28 excludes excise taxes and charges for freight, transportation, and installation. Total value of complete systems shipped in 1993

Table 25. Export Shipments of Photovoltaic Modules and Cells by Type, 1993
(Peak Kilowatts)

Item	Type			Total
	Crystalline Silicon	Thin-Film Silicon	Concentrator Silicon	
Modules	9,448	152	5	9,605
Cells . . .	5,206	2	1	5,209
Total	14,655	154	6	14,814

Note: Total may not equal sum of components due to independent rounding.

Source: Energy Information Administration, Form CE-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey."

Table 26. Destination of Photovoltaic Cell and Module Exports by Continent, 1993

Continent	Percent of Exports
Africa	7.5
Asia	31.8
Australia	.6
Europe	37.7
North America ¹	11.4
South America	11.0
Total	100.0

¹North America consists of Canada, Mexico, United States, Central America, and Caribbean countries.

Note: Total may not equal sum of components due to independent rounding.

Source: Energy Information Administration, Form CE-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey."

was \$14.1 million. Complete-system shipments in 1993 accounted for 1.4 peak kilowatts, or 9 percent of total module shipments.

Table 27. Destination of Photovoltaic Cell and Module Exports, 1993

Destination	Peak Kilowatts	Percent of Exports	Destination	Peak Kilowatts	Percent of Exports
Angola	1	(^a)	Italy	187	1.3
Argentina	795	5.4	Japan	1,440	9.7
Australia	92	0.6	Kenya	5	(^a)
Belgium	4	(^a)	Lesotho	4	(^a)
Belize	1	(^a)	Malaysia	(^a)	(^a)
Bolivia	145	1.0	Mexico	761	5.1
Botswana	273	1.8	Nepal	3	(^a)
Brazil	401	2.7	Netherlands	219	1.5
Burkina Faso	4	(^a)	Nigeria	1	(^a)
Canada	819	5.5	Norway	8	0.1
Caribbean ¹	46	0.3	Pakistan	(^a)	(^a)
Chile	96	0.6	Panama	29	0.2
China	421	2.8	Peru	102	0.7
Colombia	1	(^a)	Philippines	(^a)	(^a)
Dominican Republic	17	0.1	Senegal	(^a)	(^a)
Egypt	(^a)	(^a)	Singapore	639	4.3
El Salvador	(^a)	(^a)	South Africa	399	2.7
Ecuador	58	0.4	South Korea	282	1.9
England	20	0.1	Swaziland	(^a)	(^a)
Ethiopia	4	(^a)	Sweden	156	1.1
Finland	11	0.1	Switzerland	4	(^a)
France	(^a)	(^a)	Taiwan	83	0.6
Germany	4,972	33.6	Tanzania	7	(^a)
Ghana	14	0.1	Uganda	60	0.4
Haiti	17	0.1	United Kingdom	2	(^a)
Hong Kong	1,567	10.5	Venezuela	24	0.2
Hungary	2	(^a)	Zaire	(^a)	(^a)
India	94	0.6	Zambia	(^a)	(^a)
Indonesia	175	1.2	Zimbabwe	334	2.3
Israel	(^a)	(^a)			
Total				14,814	100.0

(^a) = Number less than 0.05, rounded to zero.

(^b) = Less than 500 peak watts.

¹Includes all Caribbean countries except Dominican Republic and Haiti.

Source: Energy Information Administration, Form CE-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey."

Table 28. Shipments of Complete Photovoltaic Module Systems, 1991-1993

Category	1991	1992	1993
Complete Photovoltaic Systems Shipped (units)	795	232	447
Modules in Complete Systems (peak kilowatts)	89	781	1,395
Modules in Systems as Percent of Total Module Shipments	1	6	9
Value of Complete Systems (thousand dollars)	5,625	7,409	14,123

Source: Energy Information Administration, Form CE-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey."

Appendix A

Survey Methodology

Photovoltaic modules and solar thermal collectors provide electricity and hot water for the Department of Energy's Child Development Center at the Forrestal Building, Washington, D.C.

Appendix A

Survey Methodology

Survey Design

The Energy Information Administration (EIA) uses the Forms CE-63A, "Annual Solar Thermal Collector Manufacturers Survey," and CE-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey," to collect annual information about the U.S. solar thermal and photovoltaic manufacturing industries. Under these surveys, the EIA obtains data from all U.S.-based manufacturers and importers of solar thermal collectors and photovoltaic devices. The survey forms and instructions are contained in Appendix B.

Respondents to the surveys are required to report data on (1) manufacturing activities, employment, and plans; and (2) total shipments, including imports and exports, type of collectors, shipment value, and shipment origin and destination. Respondents are requested to report their shipments of solar thermal collectors in terms of square feet and shipments of photovoltaic cells and modules in terms of electrical capacity, expressed in peak kilowatts.

The data collected on Forms CE-63A/B are subject to various sources of error. These sources are: (1) coverage (the list of respondents may not be complete or, on the other hand, there may be double counting); (2) nonresponse (all that are surveyed may not respond or may not provide all information requested); (3) respondents (respondents may commit errors in reporting the data); (4) processing (the data collection agency may omit or incorrectly transcribe a submission); (5) concept (the data collection elements may not measure the items they were intended to measure); and (6) adjustments (errors may be made in estimating values for missing data). Because both of the surveys are census surveys, the estimates shown in this report are not subject to sampling

error.¹⁴ Although it is not possible to present estimates of nonsampling error, precautionary steps were taken at each stage of the survey design to minimize the possible occurrence of these errors.

Survey Universe and Frame

The universe of the CE-63A/B respondents is a census of those U.S.-based companies involved in manufacturing and/or importing solar collectors. Care has been taken to establish the survey frames accurately. The frames of potential respondents are compiled from previous surveys and from information in the public domain. However, because the solar collector industry is subject to sporadic entry and exit of manufacturers and importers, the frame could possibly exclude some small companies that recently entered or re-entered the industry.

The 1991 survey frames were updated in late 1992. The 1990 survey frames were updated in late 1991 and again in early 1992. Based on results from updates of the survey frames, data for 1990 (published in *Solar Collector Manufacturing Activity 1990*) were revised in the report, *Solar Collector Manufacturing Activity 1991*.

Survey Procedures

The survey forms were sent out via first class mail to ensure their receipt only by the proper respondent organization. If the U.S. Postal Service was unable to deliver a survey form, the corrected address was obtained where possible. In a few instances, businesses that reported in earlier surveys were no longer operating and

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¹⁴Sampling error is a measure of the variation that occurs by chance because a sample rather than a complete enumeration of units is surveyed.

therefore were eliminated from the survey frames. All known companies currently conducting business in the U.S. solar collector industry were contacted before and during this survey.

Approximately half of the respondents replied to the form within the specified initial deadlines. Those that did not were mailed another form specifying a new deadline. Those that had not responded by the second deadline were telephoned to encourage submission of the forms, and those calls resulted in the submission of most of the remaining forms. During the second round of calls, data were taken over the telephone whenever possible. Data received over the phone were entered on a blank survey form. Followup procedures were carried out to reduce the nonresponse rate and possible resulting bias.

Data Editing, Analysis, and Processing

Responses to the surveys were first edited manually to verify the accuracy of the reporting and to ensure reliability of the data. All individual company responses were also compared with the data reported in previous surveys. Wherever manual editing procedures indicated discrepancies or omissions, telephone calls were made to confirm or clarify the data. Data from manually edited forms were then entered into a computer and edited a second time via an automated procedure. After the second edit, a copy of each entry and tabulated computations were reviewed by an analyst familiar with the survey and with the solar collector industry and its companies.

Response Rates

The response rate for both surveys (Forms CE-63A/B) was 100 percent. The status of companies that were mailed CE-63A survey forms for the 1993 survey is shown in Table A. The 1993 survey responses to surveys sent to 66 potential solar thermal collector companies resulted in the following performance statistics:

- Active companies: Forty-one (41) companies are known to have shipped solar thermal collectors during 1993.

- Inactive: Nineteen (19) companies on the mailing list had no shipments in 1993 but were kept on the list because they may have shipments in future years.
- Out of business: Four (4) of the companies were reported to be out of the solar thermal business during 1993, with no plans to reenter the business in a future year.
- Out of scope: Two (2) companies reported that they were not involved in solar thermal collector manufacturing or importing solar thermal collectors.

Table A1. Status of 1993 Survey Respondents

Status	Number of Companies	
	Solar Thermal (Form CE-63A)	Photovoltaic (Form CE-63B)
Active	41	19
Inactive	19	17
Out of Business	4	5
Out of Scope	2	3
Total	66	46

Sources: Energy Information Administration, Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey," and Form CE-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey."

The status of companies that were mailed CE-63B survey forms for the 1993 survey is shown in Table A. The 1993 survey responses to surveys sent to 46 potential photovoltaic cell and module companies resulted in the following performance statistics:

- Active companies: Nineteen (19) companies are known to have shipped photovoltaic cells or modules during 1993.
- Inactive: Seventeen (17) companies on the mailing list had no shipments in 1993 but were kept on the list because they may have shipments in future years.

- Out of business: Five (5) companies were reported to have exited the photovoltaic cell and module business during 1993, with no plans to reenter the business in the future.
- Out of scope: Three (3) companies reported that they were not involved in photovoltaic cell and module manufacturing or importing cells and modules.

Incomplete or Missing Data and Imputation

During the 1990 Form CE-63B survey period, one photovoltaic manufacturer was known to have shipped photovoltaic cells and modules during the first half of 1990. This photovoltaic company had gone out of business in the second half of 1990, and no data were acquired. For this company, one-half of the shipments reported for 1989 was used as the estimate of 1990 shipments.

During 1986 the solar thermal collector manufacturing industry experienced a substantial slowdown in shipments as a result of the expiration of the solar tax credit at the end of 1985 and the reduction in energy prices. Reported shipments declined from 16.4 million square feet in 1984 to 4.9 million square feet in 1986.¹⁵ Many of the 1986 shipments probably occurred during the first quarter, as customers took delivery of materials purchased in late 1985 when solar tax credits were still available. The number of companies reporting and their reported shipments for the years 1984 through 1986 are presented in Table A2.

Although reported shipments for 1985 were only 68 percent of those reported in 1984, it is likely that actual shipments were higher in 1985, which was believed to be

¹⁵The 1984 and 1986 shipment data stated here are the original survey data. These were revised by the Energy Information Administration (EIA) in *Solar Collector Manufacturing Activity 1989*, DOE/EIA-0174(89) (Washington DC, March 1991). The revised data shipments for 1984 are 17.2 million square feet, and 9.4 million square feet for 1986. The revised data include shipments of parabolic dish/trough collectors to independent power producers to generate electricity for the electric grid. For the purposes of this analysis the original data are provided.

Table A2. Number of Reporting Companies and Shipments, 1984, 1985, and 1986

Item	1984	1985 ^a	1986
Number of Companies	224	116	97
Shipments (million square feet) . .	16.4	11.1	4.9

^aIncomplete data.

Sources: 1984: Energy Information Administration, Form EIA-63, "Annual Solar Thermal Collector and Photovoltaic Module Manufacturers Survey." 1985-1986: Energy Information Administration, Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey."

a banner year because the energy tax credit expired at the end of the year. The number of companies reporting and, therefore, the reported shipments may have been low because many of the companies had gone out of business, and could not be located to collect the 1985 data when the data collection forms were mailed out more than a year later in early 1987. Shipment data for 80 companies that were in business all 3 years are presented in Table A3.

Table A3. Shipments of Companies Reporting in 1984, 1985, and 1986

Item	1984	1985 ^a	1986
Number of Companies	80	80	80
Shipments (million square feet) . .	8.7	9.9	4.6

^aIncomplete data.

Sources: 1984: Energy Information Administration, Form EIA-63, "Annual Solar Thermal Collector and Photovoltaic Module Manufacturers Survey." 1985-1986: Energy Information Administration, Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey."

For the 80 companies that were in business all 3 of the years, 1984 through 1986, shipments increased 14 percent in 1985 but decreased 54 percent in 1986. Although not conclusive, this is an indication that if all shipments for all companies in business in 1985 were reported, there could have been a substantial increase from 1984 to 1985.

During the 1980 through 1983 survey periods for solar thermal collectors, imputed shipment data for nonrespondents were included (Tables 1 and 9). Imputed data are presented in Table A4.

For the survey years 1980 through 1983, imputed solar thermal collector shipment imputed shipment data for nonrespondents were included (Tables 1 and 6).

Data Revisions

The Office of Coal, Nuclear, Electric and Alternate Fuels, Energy Information Administration, has adopted the following policy for review and correction (revision) of data it collects and publishes. The policy covers revisions to prior published data. This new policy is initially implemented with the publication of the *Solar Collector Manufacturing Activity 1992*.

1. Annual survey data are published either as *preliminary* or *final* when they first appear in a data report. Data released as *preliminary* will be identified as such. When necessary, preliminary data will be revised and declared to be *final* at the next publication of these data.
2. Monthly and quarterly survey data are published initially as *preliminary* data. They will be revised only after the completion of the data collection cycle for the full 12-month survey period. Revisions will not be made to monthly or quarterly data prior to this time.
3. The magnitude of historical data revisions experienced will be included in each data report to inform the reader about the accuracy of the data presented.

4. Revisions to data published as *final* will be made only in the event that newly available information would result in a change to published data of greater than 1 percent difference at the national level. Revisions for changes of lesser magnitudes will be made at the discretion of the Office Director.

All data from Forms CE-63A and CE-63B are published as final data. All revised data are indicated by an "R" in front of each revised data cell. No 1992 data were revised in this report.

Nondisclosure of Data

To protect the confidentiality of individual respondents' data, a policy was implemented to ensure that the reporting of survey data in this publication would not associate those data with a particular company. This is in compliance with EIA Standard No. 88-05-06, "Nondisclosure of Company Identifiable Data in Aggregate Cells." In tables where the nonzero value of a cell is composed of data from fewer than three companies or if a single company dominates a table-cell value so that the publication of the value would lead to identification of a company's data, then the EIA classifies the cell value as "sensitive," and the cell value is withheld ("W") from publication. Within a table with a sensitive cell value, selected values in other cells of the table are also withheld, as necessary, so that the sensitive cell value cannot be computed using the values in published cells.

A sensitive table-cell value can be reported, if permission is first obtained from each company (whose data contribute to the sensitivity) to publish the value. This is the only exception to the application of EIA Standard No. 88-05-06 in this report.

Table A4. Imputed Solar Thermal Collector Shipments, 1980-1983
(Thousand Square Feet)

Year	Number of Nonrespondents	Imputed Shipments		
		Total ^a	Low-Temperature ^b	Medium-Temperature ^b
1983	21	1,624	1,327	297
1982	9	249	106	143
1981	79	1,771	338	1,433
1980	43	1,631	934	697

^aImputed shipments included in total shipments.

^bImputed shipments included in low-temperature and medium-temperature shipments.

Source: Energy Information Administration, Form EIA-63, "Annual Solar Thermal Collector and Photovoltaic Module Manufacturers Survey."

Appendix B

CE-63A/B Survey Forms and Instructions

A 50-square-meter mirror is tested for quality of its reflected beam, focus control, and handling in adverse weather conditions at Solar Thermal Test Facility, Sandia National Laboratory near Albuquerque, New Mexico.

Form CE-63A
U.S. DEPARTMENT OF ENERGY
Energy Information Administration
ANNUAL SOLAR THERMAL COLLECTOR MANUFACTURERS SURVEY

This report is mandatory under FEA Act of 1974 (Public Law 93-275) and the Department of Energy Organization Act (Public Law 95-91). Provisions regarding sanctions are described in Part V, page 1 of the instructions. For the provisions concerning the confidentiality of information submitted on this form, see Part VI of the instructions. Public reporting burden for this collection of information is estimated to average 3 hours per response including the time reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to the Energy Information Administration, Office of Statistical Standards, EI-73, 1000 Independence Ave., SW, Washington, D.C. 20585, and to the Office of Information and Regulatory Affairs, Office of Management and Budget, Washington, D.C. 20503.

The reporting period for this survey is the calendar year 1993

For definitions and instructions, please refer to the General Information and Instructions section of this form.

1.0 IDENTIFICATION DATA

1.1 Respondent Identification

Complete (a) through (d) only if label is incorrect

(a) Company Name: _____
(b) Street Address: _____
_____
(c) City: _____
(d) State and Zip Code: _____

1.2 Provide the name, title, and telephone number of a person in your company to whom questions may be addressed regarding this submission.

(a) Name: _____ (c) Telephone: _____
Area Code Number
(b) Title: _____

2.0 MANUFACTURING STATUS (Please refer to the "definition" section in the instructions for key words.)

2.1 During the current reporting period, did your company:

- (a) Manufacture and ship solar thermal collectors?
(b) Cease manufacturing but continue to ship solar thermal collectors?
(c) Import and ship solar thermal collectors?
(d) Manufacture and export solar thermal collectors?

(Mark as appropriate)

☐ Yes ☐ No
☐ Yes ☐ No
☐ Yes ☐ No
☐ Yes ☐ No

2.2 If you answered "No" to all parts of question 2.1, do you plan to manufacture, import, export, and ship solar thermal collectors in the future? If yes, when? _____(year)

☐ Yes ☐ No

Note: If you answered "Yes" to any part of question 2.1, please complete the remainder of this form.

If you answered "No" to all parts of question 2.1, please complete question 8.3 and return this form in the enclosed envelope or to the address specified in the instructions.

3.0 MANUFACTURER AND MARKETING DATA

3.1 Mark the appropriate box or boxes to indicate all the solar-related activities in which your company was engaged during the survey year. Mark only those that apply to your solar activities.

- (a) ☐ Collector or system design
(b) ☐ Prototype collector development
(c) ☐ Prototype systems development
(d) ☐ Wholesale distribution
(e) ☐ Retail distribution
(f) ☐ Installation
(g) ☐ Manufacture of system-components other than those used for collector assembly
(h) ☐ Other (describe): _____

3.2 If you are planning to introduce a new solar-related product in the next calendar year, please check the appropriate box.

- (a) ☐ Low-Temperature Collector
(b) ☐ Medium-Temperature Collector
(c) ☐ High-Temperature Collector
(d) ☐ Noncollector Solar System Components
(e) ☐ Other (describe): _____

3.3 Please enter the number of person-years expended in your company in solar-related activities during the survey year. (For clarification of "person year," see the instructions.) _____person years.

3.4 What percentage of your company's total sales volume do solar-related activities comprise?

- (a) ☐ 90 - 100%
(b) ☐ 50 - 89%
(c) ☐ 10 - 49%
(d) ☐ Less than 10%

Company Name: _____ Reporting Period (Calendar Year 1993)

4.0 SOLAR THERMAL COLLECTOR-DATA. For each type of collector manufactured or imported, and shipped, enter the data for this reporting period.

ITEM	COLLECTOR TYPE								
	Low Temperature	Medium Temperature				High Temperature	Other (Specify)	Total	
	(Liquid and Air)	Air	Liquid						
	Metallic and Nonmetallic	All Medium Temperature	Integral Collector Storage/Thermosiphon	Flat Plate (pumped)	Concentrator	Evacuated Tube	Parabolic Dish/Trough		
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
4.1 Total Collector Shipments (square feet)									
4.2 Total Value of Collector Shipments in 4.1 (dollars)									
4.3 Market Sector (square feet)									
(1) Residential									
(2) Commercial									
(3) Industrial									
(4) Utility									
(5) Other (describe)									
(6) Total market sector*									
4.4 End Use (square feet)									
(1) Pool heating									
(2) Hot water									
(3) Space heating									
(4) Combined space and water heating									
(5) Space cooling									
(6) Process heating									
(7) Electricity generation									
(8) Other (describe)									
(9) Total end use*									
4.5 Imports (square feet of total in 4.1)									
4.6 Exports (square feet of total in 4.1)									
4.7 List country(ies) of Origin of Imports in 4.5									
4.8 List Country(ies) of Destination for Exports with Percent of Exports in 4.6		(%)		(%)		(%)		(%)	
		(%)		(%)		(%)		(%)	
		(%)		(%)		(%)		(%)	

*Should equal to shipments in Question 4.1.

4.9 Enter the square footage of collectors from question 4.1(i) that were shipped to

	Square feet (From 4.1(i))
(a) Exporters	_____
(b) Wholesale distributors	_____
(c) Retail Distributors	_____
(d) Installers	_____
(e) End-Users	_____
(f) Other (describe)	_____
 TOTAL	 _____

5.0 SYSTEMS DATA

5.1 Of the total collector shipments reported in question 4.1(i), how many complete systems were shipped _____ (number of systems)?

5.2 Of the collector shipments reported in question 4.1(i), enter the square footage that was sold as part of complete systems _____ (square feet).

5.3 What was the value of complete systems shipped in question 5.1 _____ (dollars)?

6.0 GEOGRAPHIC DATA

6.1 Report the percentage (%) of your company's collectors manufactured in the state listed below under Code 01-53. If some collectors were imported from another country, please indicate the percentage under Code 00.

State Code	% Collectors Imported or Manufactured in the State	State Code	% Collectors Imported or Manufactured in the State	State Code	% Collectors Imported or Manufactured in the State
00 ☐ Imported _____		18 ☐ Kentucky _____		36 ☐ Ohio _____	
01 ☐ Alabama _____		19 ☐ Louisiana _____		37 ☐ Oklahoma _____	
02 ☐ Alaska _____		20 ☐ Maine _____		38 ☐ Oregon _____	
03 ☐ Arizona _____		21 ☐ Maryland _____		39 ☐ Pennsylvania _____	
04 ☐ Arkansas _____		22 ☐ Massachusetts _____		40 ☐ Puerto Rico _____	
05 ☐ California _____		23 ☐ Michigan _____		41 ☐ Rhode Island _____	
06 ☐ Colorado _____		24 ☐ Minnesota _____		42 ☐ South Carolina _____	
07 ☐ Connecticut _____		25 ☐ Mississippi _____		43 ☐ South Dakota _____	
08 ☐ Delaware _____		26 ☐ Missouri _____		44 ☐ Tennessee _____	
09 ☐ D.C. _____		27 ☐ Montana _____		45 ☐ Texas _____	
10 ☐ Florida _____		28 ☐ Nebraska _____		46 ☐ Utah _____	
11 ☐ Georgia _____		29 ☐ Nevada _____		47 ☐ Vermont _____	
12 ☐ Hawaii _____		30 ☐ New Hampshire _____		48 ☐ Virgin Islands (U.S.) _____	
13 ☐ Idaho _____		31 ☐ New Jersey _____		49 ☐ Virginia _____	
14 ☐ Illinois _____		32 ☐ New Mexico _____		50 ☐ Washington _____	
15 ☐ Indiana _____		33 ☐ New York _____		51 ☐ West Virginia _____	
16 ☐ Iowa _____		34 ☐ North Carolina _____		52 ☐ Wisconsin _____	
17 ☐ Kansas _____		35 ☐ North Dakota _____		53 ☐ Wyoming _____	

Total Percentage _____ % (should amount to 100%)

6.2 Report the percentage (%) of your company's collectors likely to have been shipped to the state listed below under Code 01-53, this includes shipments to the state of manufacture. If some collectors were exported, please indicate the percentage under Code 00.

% Collectors Exported or Shipped		% Collectors Exported or Shipped		% Collectors Exported or Shipped	
State Code	to the State	State Code	to the State	State Code	to the State
00	☐ Exported _____	18	☐ Kentucky _____	36	☐ Ohio _____
01	☐ Alabama _____	19	☐ Louisiana _____	37	☐ Oklahoma _____
02	☐ Alaska _____	20	☐ Maine _____	38	☐ Oregon _____
03	☐ Arizona _____	21	☐ Maryland _____	39	☐ Pennsylvania _____
04	☐ Arkansas _____	22	☐ Massachusetts _____	40	☐ Puerto Rico _____
05	☐ California _____	23	☐ Michigan _____	41	☐ Rhode Island _____
06	☐ Colorado _____	24	☐ Minnesota _____	42	☐ South Carolina _____
07	☐ Connecticut _____	25	☐ Mississippi _____	43	☐ South Dakota _____
08	☐ Delaware _____	26	☐ Missouri _____	44	☐ Tennessee _____
09	☐ D.C. _____	27	☐ Montana _____	45	☐ Texas _____
10	☐ Florida _____	28	☐ Nebraska _____	46	☐ Utah _____
11	☐ Georgia _____	29	☐ Nevada _____	47	☐ Vermont _____
12	☐ Hawaii _____	30	☐ New Hampshire _____	48	☐ Virgin Islands (U.S.) _____
13	☐ Idaho _____	31	☐ New Jersey _____	49	☐ Virginia _____
14	☐ Illinois _____	32	☐ New Mexico _____	50	☐ Washington _____
15	☐ Indiana _____	33	☐ New York _____	51	☐ West Virginia _____
16	☐ Iowa _____	34	☐ North Carolina _____	52	☐ Wisconsin _____
17	☐ Kansas _____	35	☐ North Dakota _____	53	☐ Wyoming _____

Total Percentage _____ % (should amount to 100%)

7.0 PUBLICATION DATA

7.1 Do you want the name and address of your company to appear in the appendix of the next "Solar Collector Manufacturing Activity" report?

☐ Yes ☐ No

7.2 Do you want to receive a copy of the next "Solar Collector Manufacturing Activity" report?

☐ Yes ☐ No

8.0 CERTIFICATION

I certify that the historical and estimated information provided hereon and appended hereto are true, complete, and accurate to the best of my knowledge, information, and belief.

Name: _____ Title: _____

Signature: _____ Date: _____

Enter any additional remarks here: _____

Title 18 U.S.C. 1001 makes it a crime for any person knowingly and willingly to make to any Agency or Department of the United States any false, fictitious or fraudulent statement or misrepresentation as to any matter within its jurisdiction.

INSTRUCTIONS FOR FORM CE-63A, ANNUAL SOLAR THERMAL COLLECTOR MANUFACTURERS SURVEY

GENERAL INFORMATION AND INSTRUCTIONS

I. Purpose

Form CE-63A is designed to provide the data necessary for the Energy Information Administration (EIA), U.S. Department of Energy (DOE), to carry out its responsibilities for tracking collector shipments in the solar collector manufacturing industry and for providing information concerning the size and status of the industry. The publication *Solar Collector Manufacturing Activity 1993* will contain the results of this survey.

II. Who Should Respond to This Survey

Form CE-63A is to be submitted by companies (1) that manufactured and shipped (including exporting) solar thermal collectors and (2) that imported solar thermal collectors during the survey year. If you are completing this survey form for the first time but were active in the industry during the previous survey year, please photocopy the entire form and provide us with data for the previous year also.

III. Where to Submit Completed Forms

Completed and signed CE-63A forms should be returned to:

*U.S. Department of Energy
Energy Information Administration, BG-094
1000 Independence Ave., SW
Washington, D.C. 20277-7091*

Request for further information and/or additional forms may be mailed to the above address or telephoned to the survey project manager at (202) 254-5565.

IV. When to Submit Completed Forms

Completed CE-63A forms are due on the date specified in the cover letter. The survey year is from January 1 through December 31 each year.

V. Sanctions

The timely submission of Form CE-63A by those required to report is mandatory under Section 13(b) of the Federal Energy Administration Act of 1974 (FEAA) (Public Law 93-275), as amended. Failure to respond may result in a civil penalty of not more than \$2,500 for each violation, or a fine of not more than \$5,000 for each willful violation. The government may bring a civil action to prohibit reporting violations which may result in a temporary restraining order or a preliminary or permanent injunction without bond. In such civil action, the court may also issue mandatory injunctions commanding any person to comply with these reporting requirements.

VI. Provisions Regarding Confidentiality Of Information

The Office of Legal Counsel of the Department of Justice concluded on March 20, 1991, that the Federal Energy Administration Act requires the Energy Information Administration to provide company-specific data to the Department of Justice, or to any other Federal agency when requested for official use, which may include enforcement of Federal law. The information contained on this form may also be made available, upon request, to another component of the Department of Energy (DOE), to any Committee of Congress, the General Accounting Office, or other Congressional agencies authorized by law to receive such information. A court of competent jurisdiction may obtain this information in response to an order.

The information contained on this form will be kept confidential and not disclosed to the public to the extent that it satisfies the criteria for exemption under the Freedom of Information Act (FOIA), 5 U.S.C. §552, the DOE regulations, 10 C.F.R. §1004.11, implementing the FOIA, and the Trade Secrets Act, 18 U.S.C. §1905.

Upon receipt of a request for this information under the FOIA, the DOE shall make a final determination whether the information is exempt from disclosure in accordance with the procedures and criteria provided in the regulations. To assist us in this determination, respondents should demonstrate to the DOE that, for example, their information contains trade secrets or commercial or financial information whose release would be likely to cause substantial harm to their company's competitive position. A letter accompanying the submission that explains (on an element-by-element basis) the reasons why the information would be likely to cause the respondent substantial competitive harm if released to the public would aid in this determination. A new justification does not need to be provided each time information is submitted on the form, if the company has previously submitted a justification for that information and the justification has not changed.

Page 1

SPECIFIC INSTRUCTIONS

<u>Item</u>	<u>Instruction</u>
1.1 (a-d)	Make corrections to the company name or address in the spaces provided.
1.2 (a-c)	Enter the name, title, and telephone number of a company contact person who may be contacted for additional information regarding this submission.
2.1 (a-d)	Mark as appropriate the manufacturing activity conducted by your company during the current reporting period. If you answer "Yes" to any one of (a) through (d) please begin with Item 3.0 and complete the remainder of this form. If you answer "No" to all of (a) through (d) please complete only Items 2.2 and 8.0.
2.2	If you answered "No" to all of Item 2.1, please mark whether your company plans to begin or continue any manufacturing activity and, if so, in what year.
3.1 (a-h)	Report only on activities that are solar related.
3.2 (a-e)	A new solar-related product is differentiated from a modified existing product if the "new" product is different enough to warrant a new model number and requires retesting or recertification under existing industry standards.
3.3	Enter the total number of person-years expended on solar-related activities during the survey year. (See definition of "Person Year" on page 4.)
3.4	"Solar-related activities" includes all activities listed in Item 3.1.
4.1	Enter the square footage (not the number of collectors), in whole numbers (i.e., no decimals), of solar collectors by type shipped for final consumption or to another organization for resale (including exports and imports) in the appropriate collector type column. Total (column i) should be the total square footage of all collector types in that row.
4.2	Enter the total value received for the total collector shipments in Item 4.1 by type. The value reported should be the total value received for collectors only at your company's net billing price, freight-on-board factory, including charges for cooperative advertising and warranties. Do not include excise taxes, freight, or transportation. Report values to the nearest dollar. Total (column i) should be the total value of all collector types in that row.
4.3	For each appropriate sector, enter the square footage of collector shipments in Item 4.1 by collector type as precisely as possible. The market-sector categories in Item 4.3 are: - Part (1) <i>Residential</i> - Solar applications related to any building used for residential occupancy that has a system for heating or cooling, or both. - Part (2) <i>Commercial</i> - Solar applications for use in businesses where services (rather than products) are provided, such as wholesale and retail trade or health and educational services. - Part (3) <i>Industrial</i> - Solar applications for use in businesses where products (rather than services) are provided, such as the manufacture and processing of goods and basic materials. - Part (4) <i>Utility</i> - Shipments of solar thermal collectors to utilities for use in power generation or for experimental applications (includes gas and electric utilities). Includes central stations, decentralized systems or experimental applications. - Part (5) <i>Other</i> - Shipments of solar thermal collectors to other sectors such as "Government" (including the military). <i>Total market sector</i> - Sum market sector quantities and enter a total for each row (4.3(1)-(5)) in column i. Next, sum columns a through i and enter a total in row 4.3(6) for each column. These column totals should equal shipment totals entered under Item 4.1 by column. The total entered for 4.3(6) in column i should equal the total entered for Item 4.1 in column i.
4.4	For each end use, enter the square footage of collector shipments in Item 4.1 by collector type as precisely as possible. The end-use categories in Item 4.4 are: - Part (1) <i>Pool Heating</i> - Self-explanatory. - Part (2) <i>Hot Water</i> - Shipments of solar thermal collectors used only for water heating. - Part (3) <i>Space Heating</i> - Shipments of solar thermal collectors used only for space heating. - Part (4) <i>Combined space and water heating</i> - Shipments of solar thermal collectors are used in combination for space and water heating. - Part (5) <i>Space cooling</i> - Shipments of solar thermal collectors used for space cooling (air conditioning) or for space cooling in combination with water and/or space heating. - Part (6) <i>Process heating</i> - Shipments of solar thermal collectors used for industrial process heating. - Part (7) <i>Electricity Generation</i> - Shipments of solar thermal collectors such as concentrators, linear fresnel lens, heliostats, parabolic dishes, and parabolic troughs used as steam generators to power electric generators. - Part (8) <i>Other</i> - Shipments of solar thermal collectors for other uses such as cooking food, water pumping, water purification, desalinization, distilling, etc.

SPECIFIC INSTRUCTIONS

<u>Item</u>	<u>Instruction</u>
4.4	Total end use - Sum end-use quantities and enter a total for each row [4.4(1)-(8)] in column i. Next, sum columns a through i and enter a total in row 4.4(9) for each column. These column totals should equal shipment totals entered under Item 4.1 by column. The total entered for 4.4(9) in column i should equal the total entered for Item 4.1 in column i.
4.5	Enter the square footage by collector type. This amount represents the portion of total collector shipments entered in Item 4.1 that were imported and shipped by your company.
4.6	Enter the square footage by collector type. This amount represents the portion of total collector shipments entered in Item 4.1 that were manufactured for export and shipped (sold) to another country.
4.7	List the country(ies) from which solar collectors reported in Item 4.5 were imported.
4.8	List the country(ies) to which solar collectors reported in Item 4.6 were exported, and percent of exports in Item 4.6 for each country listed.
4.9	Of the collectors reported in Item 4.1(i), report in square feet, the recipients of solar thermal collectors immediately following manufacturing or warehousing. If recipients overlap (for example, the recipient is both a wholesale distributor and an installer) report the recipients in the higher category (i.e., a is higher than b, b is higher than c, etc.).
5.1	Enter number of complete systems shipped from the total in Item 4.1(i).
5.2	Of the collectors reported in Item 4.1(i), enter the square footage that was sold as complete systems. (Complete system is defined as unit with all the necessary functional components, except for installation materials. These include thermosiphon systems, integral collector storage systems, packaged systems, or system kits.)
5.3	The value reported should be total value received for the complete systems at your company's net billing price, freight-on-board factory, including charges for cooperative advertising and warranties. (It should include the value of associated collectors.) Do not include excise taxes, freight or transportation charges, or installation charges. Report values to the nearest dollar.
6.1	Please identify only the State of final assembly of the collector. Please be certain to provide total percentage calculations.
6.2	Refers to collector shipments only. Indicate the last State of destination of which you are aware.
7.1	Mark as appropriate.
7.2	Mark as appropriate.
8.0	Self-explanatory.

DEFINITIONS

1. **Air Collector** - A medium-temperature solar thermal collector used predominantly in space-heating application and which utilizes pumped air as the heat-transfer medium.
2. **Concentrator** - A reflective or refractive device that focuses solar rays onto an area smaller than the reflective or refractive surface, resulting in higher intensity solar rays at the point of focus.
3. **Evacuated-Tube Collector** - A solar thermal collector in which the collector fluid flows through an absorber tube that is contained inside an evacuated glass cylinder.
4. **Export (solar)** - A shipment of solar thermal collectors and/or photovoltaic devices sent from the United States and any of its territories to a foreign country.
5. **Flat Plate (pumped)** - A medium-temperature solar thermal collector, typically made with a metal frame, glazing, absorbers (usually metal), and insulation, that uses pumped liquid as the heat-transfer medium; predominantly used in water-heating applications.
6. **High-Temperature Collectors** - A solar thermal collector that generally operates at temperatures above 180 degrees Fahrenheit.
7. **Import (solar)** - A shipment of solar thermal collectors and/or photovoltaic devices into the United States and any of its territories from foreign countries.
8. **Integral Collector Storage (ICS)** - A solar thermal collector in which incident solar radiation is absorbed directly by the storage medium.
9. **Liquid Collector** - A medium-temperature solar thermal collector used predominantly in water heating, utilizing pumped liquid as the heat-transfer medium.
10. **Low-Temperature Collectors** - A solar thermal collector that generally operates at temperatures below 100 degrees Fahrenheit.
11. **Medium-Temperature Collectors** - A solar thermal collector that generally operates in the temperature range of 140 degrees Fahrenheit to 180 degrees Fahrenheit but can also operate at a temperature as low as 100 degrees Fahrenheit.
12. **Parabolic Dish** - A high temperature (above 180 degrees Fahrenheit) solar thermal concentrator, generally bowl-shaped, with the capacity for tracking the sun using two axes of rotation.
13. **Parabolic Trough** - A high temperature (above 180 degrees Fahrenheit) solar thermal concentrator with the capacity for tracking the sun using one axis of rotation.
14. **Person Year** - One whole year, or fraction thereof, worked by an employee. It is expressed as a quotient (to two decimal places) of the time units worked during a year (hours, weeks, months) divided by the like total time units in a year. For example: 80 hours worked is 0.04 (rounded) of a person year; 3 weeks worked is 0.06 (rounded) of a person year; 12 months worked is 1.0 person year.
15. **Solar Thermal Collector** - A device designed to receive solar radiation and convert it into thermal energy. Normally, a solar thermal collector includes a frame, glazing, and an absorber, together with appropriate insulation. The heat collected by the solar thermal collector may be used immediately or stored for later use.
16. **Thermosiphon System** - A solar collector system for water heating in which circulation of the collection fluid through the storage loop is provided solely by the temperature and density difference between the hot and cold fluids.

Form CE-63B
U.S. DEPARTMENT OF ENERGY
Energy Information Administration
ANNUAL PHOTOVOLTAIC MODULE/CELL MANUFACTURERS SURVEY

This report is mandatory under FEA Act of 1974 (Public Law 93-275) and the Department of Energy Organization Act (Public Law 95-91). Provisions regarding sanctions are described in Part V, page 1 of the instructions. For the provisions concerning the confidentiality of information submitted on this form, see Part IV of the instructions. *Public reporting burden for this collection of information is estimated to average 3 hours per response* including the time reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to the Energy Information Administration, Office of Statistical Standards, EI-73, 1000 Independence Ave., SW, Washington, D.C. 20585, and to the Office of Information and Regulatory Affairs, Office of Management and Budget, Washington, D.C. 20503.

The reporting period for this survey is the calendar year 1993

For definitions and instructions, please refer to the General Information and Instructions section of this form.

1.0 IDENTIFICATION DATA

1.1 Respondent Identification

Complete (a) through (d) only if label is incorrect

- (a) Company Name: _____
- (b) Street Address: _____
- (c) City: _____
- (d) State and Zip Code: _____

1.2 Provide the name, title, and telephone number of a person in your company to whom questions may be addressed regarding this submission.

- (a) Name: _____ (c) Telephone: _____
Area Code Number
- (b) Title: _____

2.0 MANUFACTURING STATUS (Please refer to the "definition" section in the instructions for key words.)

2.1 During the current reporting period, did your company:

- (a) Manufacture and ship photovoltaic modules/cells?
(b) Cease manufacturing but continue to ship photovoltaic modules/cells?
(c) Import and ship photovoltaic modules/cells?
(d) Manufacture and export photovoltaic modules/cells?

(Mark as appropriate)

☐ Yes	☐ No
☐ Yes	☐ No
☐ Yes	☐ No
☐ Yes	☐ No

2.2 If you answered "No" to all parts of question 2.1, do you plan to manufacture, import, export, and ship photovoltaic modules/cells in the future? If yes, when? _____(year)

- ☐ Yes ☐ No

Note: If you answered "Yes" to any part of question 2.1, please complete the remainder of this form.

If you answered "No" to all parts of question 2.1, please complete question 7.0 and return this form in the enclosed envelope or to the address specified in the instructions.

3.0 MANUFACTURER AND MARKETING DATA

3.1 Mark the appropriate box or boxes to indicate all the photovoltaic-related activities in which your company was engaged during the survey year. Mark only those that apply to your photovoltaic activities.

- (a) ☐ Cell manufacturing
(b) ☐ Module or system design
(c) ☐ Prototype module development
(d) ☐ Prototype systems development
(e) ☐ Wholesale distribution of modules
(f) ☐ Retail distribution of modules
(g) ☐ Installation
(h) ☐ Manufacture of system components-other than those used for module assembly
(i) ☐ Other (describe): _____

3.2 If you are planning to introduce a new photovoltaic-related product in the next calendar year, please check the appropriate box.

- (a) ☐ Single-crystal silicon modules/cells
(b) ☐ Cast silicon modules/cells
(c) ☐ Ribbon silicon modules/cells
(d) ☐ Amorphous silicon modules/cells
(e) ☐ Other (thin film)-specify: _____
(f) ☐ Other (flat plate)-specify: _____
(g) ☐ Other (concentrator)-specify: _____
(h) ☐ Nonmodule system components-specify: _____

3.3 Please enter the number of person-years expended in your company in photovoltaic-related activities during the survey year. (For clarification of "person year," see the instructions.) _____ person years.

Company Name:

Reporting Period (Calendar year 1993)

4.0 PHOTOVOLTAIC CELL AND MODULE SHIPMENT DATA. For each type of module/cell manufactured or imported, and shipped, enter the data for this reporting period.

ITEM	MODULE/CELL TYPE							
	Crystalline Silicon			Thin Film		Concentrator	Other	Total
	Single Crystal (Czochralsky) (a)	Cast (b)	Ribbon (c)	Amorphous Silicon (d)	Other (Specify) (e)	(f)	(Specify) (g)	(h)
4.1 Quantity of Shipments (in peak kilowatts)								
(1) Total net module shipments								
(2) Total net cell shipments								
(3) Total quantity of shipments								
4.2 Value of Shipments (dollars)								
(1) Value of module shipments								
(2) Value of cell shipments								
(3) Total value of shipments								
4.3 End Use (in peak kilowatts)								
(1) Health								
(2) Water pumping								
(3) Transportation								
(4) Communication								
(5) Consumer goods								
(6) Electric generation								
(a) Grid interactive								
(b) Other remote (stand alone)								
(7) To original equipment manufacturers (Non-PV)								
(8) Other users (specify):								
(9) Total end use*								
4.4 Market Sector (in peak kilowatts)								
(1) Government								
(2) Residential								
(3) Commercial								
(4) Industrial								
(5) Utility								
(6) Transportation								
(7) Other sectors (specify):								
(8) Total market sector*								
4.5 Imports (in peak kilowatts)								
(1) Modules								
(2) Cells								
(3) Total imports								
4.6 Exports (in peak kilowatts)								
(1) Modules								
(2) Cells								
(3) Total exports								
4.7 List country(ies) of Origin of Imports in 4.5								
4.8 List Country(ies) of Destination for Exports with Percent of Exports in 4.6		(%)		(%)		(%)		(%)
*Should equal total shipments in Question 4.1(3).		(%)		(%)		(%)		(%)
		(%)		(%)		(%)		(%)

CE-63B

4.9 Enter the quantity (in peak kilowatts) of cells and modules reported in 4.1(1)(h) and 4.1(2)(h) that were shipped to

	Modules (From 4.1(1)(h))	Cells (From 4.1(2)(h))
(a) Exporters	_____	_____
(b) Module Manufacturers	XXXXXXXXXX	_____
(c) Wholesale Distributors	_____	_____
(d) Retail Distributors	_____	_____
(e) Installers	_____	_____
(f) End-Users	_____	_____
(g) Other (describe)	_____	_____
TOTAL	_____	_____

5.0 SYSTEM DATA

5.1 Of the total modules shipped in 4.1(1)(h), how many complete systems were shipped _____ (number of systems)?

5.2 Of the modules shipped in 4.1(1)(h), enter the peak kilowatts that were sold as part of complete systems _____ (kilowatts)?

5.3 What was the value of complete systems shipped in question 5.1 _____ (dollars)?

6.0 PUBLICATION DATA

6.1 Do you want the name and address of your company to appear in the appendix of the next "Solar Collector Manufacturing Activity" report?

☐ Yes ☐ No

6.2 Do you want to receive a copy of the next "Solar Collector Manufacturing Activity" report?

☐ Yes ☐ No

7.0 CERTIFICATION

I certify that the historical and estimated information provided hereon and appended hereto are true, complete, and accurate to the best of my knowledge, information, and belief.

Name: _____ Title: _____

Signature: _____ Date: _____

Enter any additional remarks here: _____

Title 18 U.S.C. 1001 makes it a crime for any person knowingly and willingly to make to any Agency or Department of the United States any false, fictitious or fraudulent statement or misrepresentation as to any matter within its jurisdiction.

INSTRUCTIONS FOR FORM CE-63B, ANNUAL PHOTOVOLTAIC MODULE/CELL MANUFACTURERS SURVEY

GENERAL INFORMATION AND INSTRUCTIONS

I. Purpose

Form CE-63B is designed to provide the data necessary for the Energy Information Administration (EIA), U.S. Department of Energy (DOE), to carry out its responsibilities for tracking collector shipments in the solar collector manufacturing industry and for providing information concerning the size and status of the industry. The publication *Solar Collector Manufacturing Activity 1993* will contain the results of this survey.

II. Who Should Respond to This Survey

Form CE-63B is to be submitted by companies that (1) manufactured and shipped (including exporting) photovoltaic cells and modules and (2) that imported photovoltaic cells and modules during the survey year. If you are completing this survey form for the first time but were active in the industry during the previous survey year, please photocopy the entire form and provide us with data for the previous year also.

III. Where to Submit Completed Forms

Completed and signed CE-63B forms should be returned to:

*U.S. Department of Energy
Energy Information Administration, BG-094
1000 Independence Ave., SW
Washington, D.C. 20277-7091*

Request for further information and/or additional forms may be mailed to the above address or telephoned to the survey project manager at (202) 254-5565.

IV. When to Submit Completed Forms

Completed CE-63B forms are due on the date specified in the cover letter. The survey year is from January 1 through December 31 each year.

V. Sanctions

The timely submission of Form CE-63B by those required to report is mandatory under Section 13(b) of the Federal Energy Administration Act of 1974 (FEAA) (Public Law 93-275), as amended. Failure to respond may result in a civil penalty of not more than \$2,500 for each violation, or a fine of not more than \$5,000 for each willful violation. The government may bring a civil action to prohibit reporting violations which may result in a temporary restraining order or a preliminary or permanent injunction without bond. In such civil action, the court may also issue mandatory injunctions commanding any person to comply with these reporting requirements.

VI. Provisions Regarding Confidentiality Of Information

The Office of Legal Counsel of the Department of Justice concluded on March 20, 1991, that the Federal Energy Administration Act requires the Energy Information Administration to provide company-specific data to the Department of Justice, or to any other Federal agency when requested for official use, which may include enforcement of Federal law. The information contained on this form may also be made available, upon request, to another component of the Department of Energy (DOE), to any Committee of Congress, the General Accounting Office, or other Congressional agencies authorized by law to receive such information. A court of competent jurisdiction may obtain this information in response to an order.

The information contained on this form will be kept confidential and not disclosed to the public to the extent that it satisfies the criteria for exemption under the Freedom of Information Act (FOIA), 5 U.S.C. §552, the DOE regulations, 10 C.F.R. §1004.11, implementing the FOIA, and the Trade Secrets Act, 18 U.S.C. §1905.

Upon receipt of a request for this information under the FOIA, the DOE shall make a final determination whether the information is exempt from disclosure in accordance with the procedures and criteria provided in the regulations. To assist us in this determination, respondents should demonstrate to the DOE that, for example, their information contains trade secrets or commercial or financial information whose release would be likely to cause substantial harm to their company's competitive position. A letter accompanying the submission that explains (on an element-by-element basis) the reasons why the information would be likely to cause the respondent substantial competitive harm if released to the public would aid in this determination. A new justification does not need to be provided each time information is submitted on the form, if the company has previously submitted a justification for that information and the justification has not changed.

SPECIFIC INSTRUCTIONS

<u>Item</u>	<u>Instructions</u>
1.1	(a-d) Make corrections to the company name or address in the spaces provided.
1.2	(a-c) Enter the name, title, and telephone number of a company contact person who may be contacted for additional information regarding this submission.
2.1	(a-d) Mark as appropriate the manufacturing activity conducted by your company during the current reporting period. If you answer "Yes" to any one of (a) through (d) please begin with Item 3.0 and complete the remainder of this form. If you answer "No" to all of (a) through (d) please complete only Items 2.2 and 7.0.
2.2	If you answered "No" to all of Item 2.1, please mark whether your company plans to begin or continue any manufacturing activity, and if so, in what year.
3.1	(a-i) Report only on activities that are photovoltaic related.
3.2	(a-h) A new photovoltaic product is differentiated from a modified existing product if the "new" product is different enough to warrant a new model number and requires retesting or recertification under existing industry standards.
3.3	Enter the total number of person-years expended on photovoltaic-related activities during the survey year. (See definition of "Person Year" on page 4.)
4.1	Quantity (in peak kilowatts) of photovoltaic module/cell shipments for terrestrial use only. Photovoltaic modules/cells intended for applications in space programs (satellites, military projects, etc.) are to be excluded.
	Part (1) <i>Total net module shipments</i> - Enter the quantity in peak kilowatts (not the number of modules) of net photovoltaic modules shipped for final consumption or to another organization for resale (including exports and imports) in the appropriate module/cell type column. (Net photovoltaic module is defined on page 4.) When exported, incomplete modules and un-encapsulated cells are also included. Total (column h) should be the total peak kilowatts of all module types in that row.
	Part (2) <i>Total net cell shipments</i> - Enter the quantity in peak kilowatts (not the number of cells) of net photovoltaic cells shipped to end-users or non-photovoltaic original equipment manufacturers (including exports and imports) in the appropriate module/cell type column. (Net photovoltaic cell is defined on page 4.) Photovoltaic cells which are shipped to U.S. based photovoltaic module manufacturers should <u>not</u> be reported. Incomplete cells, such as wafers, should <u>not</u> be reported. Total (column h) should be the total peak kilowatts of all module types in that row.
	<i>Total quantity of shipments</i> - Sum under 4.1(3) the quantities of 4.1(1) and 4.1(2) for all types (columns a through g) and Totals, (column h).
4.2	Value (in dollars) of photovoltaic module/cell shipments in Item 4.1. The value reported should be total value received for modules/cells only at your company's net billing price, freight-on-board factory, including charges for cooperative advertising and warranties. Do not include excise taxes, freight, or transportation. Report values to the nearest dollar.
	Part (1) <i>Value of net module shipments</i> - Enter under 4.2(1) the total value of net photovoltaic modules in Item 4.1(1). Total (column h) should be the total value of all module types in that row.
	Part (2) <i>Value of net cell shipments</i> - Enter under 4.2(2) the total value of net photovoltaic cells in Item 4.1(2). Total (column h) should be the total value of all cell types in that row.
	<i>Total value of shipments</i> - Sum under 4.2(3) the values of 4.2(1) and 4.2(2) for all types (columns a through g) and Totals, (column h).
4.3	For each end use, enter the peak kilowatt quantity of module/cell shipments in Item 4.1(3) by type as precisely as possible. The end-use categories in Item 4.3 are:
	Part (1) <i>Health</i> - Photovoltaic modules/cells used in health/medical applications such as those used for powering medical refrigerators, medical equipment and for water purifications.
	Part (2) <i>Water Pumping</i> - Photovoltaic modules/cells used for pumping water for agricultural, land reclamation, commercial and other similar applications where water pumping is the main use.
	Part (3) <i>Transportation</i> - Photovoltaic modules/cells used on boats, cars, and recreational vehicles; and those used for transportation support systems such as signs, illumination, warning signals, etc.
	Part (4) <i>Communication</i> - Photovoltaic modules/cells employed to power fixed base telecommunications equipment, such as mountain-top repeater stations. Modules/cells issued for space applications are <u>not</u> to be included in this survey.
	Part (5) <i>Consumer goods</i> - Photovoltaic modules/cells used to power products such as portable radios, toys, watches, calculators, small battery chargers, etc. (Please specify on the bases of stabilized full sun rating.)
	Part (6) <i>Electric Generation</i> - Grid interactive and remote or stand alone power generation for general uses, including those for grid distribution and general remote uses like: residential power and power for mobile homes.

SPECIFIC INSTRUCTIONS

<u>Item</u>	<u>Instructions</u>
4.3	Part (7) <i>To original equipment manufacturers (non-PV)</i> - Photovoltaic cells or modules shipped to non-photovoltaic original equipment manufacturers (OEM) that combines the cells into existing or newly developed product lines such as boats, cars, etc. Part (8) <i>Other uses</i> - Shipments of photovoltaic cells and modules for other uses such as cooking food, desalinization, distilling, etc. Total end use - Sum end-use quantities and enter a total for each row [4.3(1)-(8)] in column h. Next, sum columns a through h and enter a total in row 4.3(9) for each column. These column totals should equal shipment totals entered under Item 4.1(3) by column. The total entered for 4.3(9) in column h should equal the total entered for Item 4.1(3) in column h.
4.4	For each appropriate sector, enter the peak kilowatt quantity of module/cell shipments in Item 4.1(3) by type as precisely as possible. The market-sector categories in Item 4.4 are: Part (1) <i>Government</i> - Photovoltaic modules/cells for terrestrial use and employed to produce power for any branch of the U.S. Federal, State, and local government (including the military and including such uses as research, development, and demonstration projects). This excludes foreign government, which should be reported in Item 4.4 Part (7), Other sectors. Part (2) <i>Residential</i> - Photovoltaic modules/cells that are used in distributed, grid connected photovoltaic systems to provide power for residential applications. Part (3) <i>Commercial</i> - Photovoltaic modules/cells employed to produce power for commercial establishments, such as office buildings, private hospitals, private schools, retail establishments, etc. (Publicly owned schools, hospitals, and other institutions should be listed under government.) Part (4) <i>Industrial</i> - Photovoltaic modules employed to produce power for industrial applications. Includes both grid and non-grid connected systems. Part (5) <i>Utility</i> - Photovoltaic modules/cells used to produce power at an utility owned system including central stations, decentralized systems or experimental applications. Part (6) <i>Transportation</i> - Photovoltaic modules/cells used to produce power on boats, cars, and recreational vehicles; and those used to power transportation support systems such as signs, illumination, warning signals, etc. Part (7) <i>Other sectors</i> - Self explanatory. Total market sector - Sum market sector quantities and enter a total for each row [4.4(1)-(7)] in column h. Next, sum columns a through h and enter a total in row 4.4(8) for each column. These column totals should equal shipment totals entered under Item 4.1(3) by column. The total entered for 4.4(8) in column h should equal the total entered for Item 4.1(3) in column h.
4.5	Quantity (in peak kilowatts) of imported photovoltaic modules/cells that represents the portion of photovoltaic shipments entered in Item 4.1 (1) and (2) by module/cell type that were imported and shipped by your company. Part (1) <i>Modules</i> - Enter the peak kilowatts of imported photovoltaic modules by type. This amount represents the portion of total shipments in Item 4.1(1). Total (column h) should be the total peak kilowatts of all imported module types in that row. Part (2) <i>Cells</i> - Enter the peak kilowatts of imported photovoltaic cells by type. This amount represents the portion of total shipments in Item 4.1(2). Total (column h) should be the total peak kilowatts of all imported cell types in that row. Total Imports - Sum under 4.5(3) the quantities of 4.5(1) and 4.5(2) for all types (columns a through g) and Total, (column h).
4.6	Quantity (in peak kilowatts) of exported photovoltaic modules/cells that represents the portion of photovoltaic shipments entered in Item 4.1(1) and (2) by module/cell type that were exported by your company. Part (1) <i>Modules</i> - Enter the peak kilowatts of exported photovoltaic modules by type. This amount represents the portion of total shipments in Item 4.1(1). Total (column h) should be the total peak kilowatts of all exported module types in that row. Part (2) <i>Cells</i> - Enter the peak kilowatts of exported photovoltaic cells by type, including those cells that were shipped to foreign photovoltaic module manufacturers. This amount represents the portion of total shipments in Item 4.1(2). Total (column h) should be the total peak kilowatts of all exported cell types in that row. Total Exports - Sum under 4.6(3) the quantities of 4.6(1) and 4.6(2) for all types (columns a through g) and Total, (column h).
4.7	List the country(ies) from which photovoltaic modules/cells reported in Item 4.5 were imported.
4.8	List the country(ies) to which photovoltaic modules/cells reported in Item 4.6 were exported, and percent of exports in Item 4.6 for each country listed.
4.9	Of the modules/cells reported in Item 4.1 (1) and (2), report in peak kilowatts, the recipients of modules/cells immediately following manufacturing or warehousing. If recipients overlap (for example, the recipient is both a wholesaler distributor and an installer), report the recipients in the higher category (i.e., a is higher than b, b is higher than c, etc.).

SPECIFIC INSTRUCTIONS

<u>Item</u>	<u>Instructions</u>
5.1	Enter the number of complete systems shipped from the total modules in Item 4.1(1) (column h).
5.2	Of the modules reported in Item 4.1(1)(h), enter the peak kilowatts that were sold as complete systems. (Complete system is defined as a unit with all the necessary functional components, except for installation materials.)
5.3	The value reported should be the total value received for the complete systems at your company's net billing price, freight-on-board factory, including charges for cooperative advertising and warranties. (It should include the value of the associated modules.) Do not include excise taxes, freight or transportation charges, or installation charges. Report values to the nearest dollar.
6.1	Mark as appropriate.
7.0	Self-explanatory.

DEFINITIONS

1. Amorphous Silicon - An alloy of silica and hydrogen, with an irregular internal atomic arrangement, that can be deposited in thin-film layers (a few micrometers in thickness) by means of a number of deposition methods to produce thin-film photovoltaic cells on glass, metal, or plastic substrates.
2. Cast Silicon - Crystalline silicon obtained by pouring pure molten silicon into a vertical mold and adjusting the temperature gradient along the mold volume during cooling to obtain slow, vertically-advancing crystallization of the silicon. The polycrystalline ingot thus formed is composed of large, relatively parallel, interlocking crystals. The cast ingots are sawed into wafers for further fabrication into photovoltaic cells. Cast-silicon wafers and ribbon-silicon sheets fabricated into cells are usually referred to as polycrystalline photovoltaic cells.
3. Concentrator - A reflective or refractive device that focuses solar rays onto an area smaller than the reflective or refractive surface, resulting in higher intensity solar rays at the point of focus.
4. Export (solar) - A shipment of solar thermal collectors and/or photovoltaic devices sent from the United States and any of its territories to a foreign country.
5. Import (solar) - A shipment of solar thermal collectors and/or photovoltaic devices into the United States and any of its territories from foreign countries.
6. Peak Kilowatt (kWp) - One thousand peak watts.
7. Net Photovoltaic Cell Shipment - The difference between photovoltaic cell shipments and photovoltaic cell purchases.
8. Net Photovoltaic Module Shipment - The difference between photovoltaic module shipments and photovoltaic module purchases.
9. Peak Watt - A manufacturer's unit indicating the amount of power a photovoltaic cell or module will produce at standard test conditions (normally 1,000 watts per square meter and 25 degrees Celsius).
10. Person Year - One whole year, or fraction thereof, worked by an employee. It is expressed as a quotient (to two decimal places) of the time units worked during a year (hours, weeks, months) divided by the like total time units in a year. For example: 80 hours worked is 0.04 (rounded) of a person-year; 3 weeks worked is 0.06 (rounded) of a person-year; 12 months worked is 1.00 person-year.
11. Photovoltaic Cell - An electronic device consisting of layers of semiconductor materials fabricated to form a junction (adjacent layers of materials with different electronic characteristics) and electrical contacts, and being capable of converting incident light directly into electricity (direct current).
12. Photovoltaic Module - An integrated assembly of interconnected photovoltaic cells designed to deliver a selected level of working voltage and current at its output terminals, packaged for protection against environment degradation, and suited for incorporation in photovoltaic power systems.
13. Ribbon Silicon - Sheets of crystalline silicon fabricated by a variety of solidification (crystallization) methods whereby thin silicon sheets are withdrawn from a pool of relatively pure molten silicon. The methods include: edge-defined, film-fed growth (EFG) and dendritic-web growth.
14. Silicon - A nonmetallic element with atomic number 14 and valence of 4. It occurs extensively in earth's crust as silica (SiO_2) and silicates (SiO_2 + other elements and/or molecules). As a chemically altered extract, silicon is used in alloys and electronic devices such as photovoltaic cells.
15. Single Crystal Silicon (Czochralski) - An extremely pure form of crystalline silicon produced by the Czochralski method of dipping a single crystal seed into a pool of molten silicon under high vacuum conditions and slowly withdrawing a solidifying single crystal boule of silicon. The boule is sawed into thin silicon wafers and fabricated into single-crystal photovoltaic cells.

Appendix C

Respondents to the 1993 Solar Thermal Collector Manufacturers Survey (Form CE-63A)

Solar thermal collector used in the air-heating system at Ford Motor Company's Chicago Stamping Plant.

Appendix C

Respondents to the 1993 Solar Thermal Collector Manufacturers Survey (Form CE-63A)

Of the companies reporting data on Form CE-63A, 41 gave permission to have their company name and address listed in this publication.

Access Technology Corporation
360 Center Street
Bangor, ME 04401

American Energy Technologies
P.O. Box 1865
Green Cove Spring, FL 32043

American Solar Network, Ltd.
5840 Gibbons Drive, Suite H
Carmichael, CA 95608

Applied Solar Products
4580 Almaden Expressway
San Jose, CA 95118

Aquatherm Industries, Inc.
1985 Rutgers University Blvd.
Lakewood, NJ 08701

Astron Technologies
4001 Atlantic Avenue
Raleigh, NC 27604

BC Solar
South 401 Hodges Road
Greenacres, WA 99016

Bio-Energy Systems, Inc.
P.O. Box 191, 48 Canal Street
Ellenville, NY 12428

BSAR Solar
980 Santa Estella
Solana Beach, CA 92075

Caribe Sol De Puerto Rico
Apartado 190
Mayaguez, PR 00709

Conserval Systems, Inc.
4242 Ridge Lea Road, Suite 1
Buffalo, NY 14226

Cummins Power Generation
P.O. Box #3005 M/C 60125
Columbus, IN 47202-3005

FAFCO, Inc.
2690 Middlefield Road
Redwood City, CA 94063

GS Energy Industries, Inc.
108 Jefferson Avenue
Des Moines, IA 50314

Haleakala Resources, Inc.
P.O. Box 786
Puunene, HI 96784

Hanson Energy Products
P.O. Box 1086
Rockland, ME 04841

Heliocol USA, Inc.
927 Fern St., #200
Altamonte-Springs, FL 32701

Heliodyne, Inc.
4910 Seaport Ave.
Richmond, CA 94804

Industrial Solar Technology
5771 W. 52nd Ave.
Denver, CO 80212

Keenan Solar, Inc.
7000 SW 22nd Ct., 127C
Davie, FL 33317

Professional Solar Products
31125 Via Colinas #904
West Lake Village, CA 91362

Puerto Rico Solar Products
P.O. Box 702
Moca, PR 00716

Radco Products, Inc.
2877 Industrial Parkway
Santa Maria, CA 93455

S & L Solar System Co., Inc.
Box 1535
Carolina, PR 00984

Sage Advance Corporation
P.O. Box 23136
Eugene, OR 97402

Sealed Air Corp.
3433 Arden Road
Hayward, CA 94545

SEMCO
901 21st Street, N.W.
Albuquerque, NM 87104

Solahart USA
155 Mata Way, Suite #109
San Marcos, CA 92069

Solar Alternative, Inc.
P.O. Box 739
Brattleboro, VT 05301

Solar Development, Inc.
3607A Prospect Avenue
Riviera Beach, FL 33404

Solar Energy and Resources, Inc.
P.O. Box 2929
Bayamon, PR 00621

Solar Living, Inc.
P.O. Box 12
Netcong, NJ 07857

SunEarth, Inc.
4315 Santa Ana St.
Ontario, CA 91761

Sun Quest, Inc.
1555 Rankin Ave.
Newton, NC 28658

Sun Ray Solar Heaters
1943-A Friendship Drive
El Cajon, CA 92020

Sun Trapper Solar Systems, Inc.
12118 Radium
San Antonio, TX 78216

Sunwatt Corp
RFD Box 751
Addison, ME 04606

Thermal Conversion Technology, Inc.
P.O. Box 3887
Sarasota, FL 34230

Thermomax USA, LTD
6193 Wooder Run Drive
Columbia, MD 21044

Universal Solar Products
P.O. Box 364027
San Juan, PR 00936-4027

Virginia Solar Components, Inc.
Rt. 4 Highway 29 South
Rustburg, VA 24588

Appendix D

Respondents to the 1993 Photovoltaic Module/Cell Manufacturers Survey (Form CE-63B)

Thin-film photovoltaic modules, designed for use in utility applications.

Appendix D

Respondents to the 1993 Photovoltaic Module/Cell Manufacturers Survey (Form CE-63B)

Of the companies reporting data on Form CE-63B, 18 gave permission to have their company name and address listed in this publication.

A Y McDonald Mfg. Co.
Box 508
4800 Chavenelle Rd.
Dubuque, IA 52004-0508

Advanced Photovoltaic Systems, Inc.
P.O. Box 7093
Princeton, NJ 08543

AstroPower, Inc.
Solar Park
Newark, DE 19716-2000

BC Solar
South 401 Hodges Road
Greenacres, WA 99016

EPV - Energy Photovoltaics
P.O. Box 7456
Princeton, NJ 08543

Iowa Thin Film Technologies
ISU Research Park #607
Ames, IA 50010

Kyocera America, Inc.
8611 Balboa Avenue
San Diego, CA 92123

Midway Labs, Inc.
2255 E. 75th Street
Chicago, IL 60649

Mobil Solar Energy Co.
4 Suburban Park Drive
Billerica, MA 01821

Sanyo Energy Corporation
2011 N. Collins
Suite 607
Richardson, TX 75080

Siemens Solar Industries
P.O. Box 6032
4650 Adhor Lane
Camarillo, CA 93010

Solarex Corporation
630 Solarex Court
Frederick, MD 21701

Solec International, Inc.
12533 Chadron Avenue
Hawthorne, CA 90250

Spire Corporation
One Patriots Park
Bedford, MA 01730

SunPower Corporation
435 Indio Way
Sunnyvale, CA 94086

Sunwatt Corporation
RFD Box 751
Addison, ME 04606

Tideland Signal Co.
P.O. Box 52430
Houston, TX 77052

Utility Power Group
9410 Desoto Ave., Unit G.
Chatsworth, CA 91311

Appendix E

U.S. Customary Units of Measurement, International System of Units (SI), and Selected Data Tables in SI Metric Units

Flat-plate solar thermal collectors installed on a restaurant in Washington, D.C.

Appendix E

U.S. Customary Units of Measurements, International System of Units (SI), and Selected Data Tables in SI Metric Units

The standard factor for conversion from U.S. customary to International System of Units (SI) unit of measure is shown in Table E1.

Table E1. Conversion Factor for U.S. Customary and SI Units of Measurement

To Convert From:	To:	Multiply By:
Area		
Square Feet (ft ²)	Square Meters (m ²)	0.09290304

Note: The conversion factor is exact and all subsequent digits are zero.

Source: Table E1 is patterned after Table 3, "Conversion Factors for SI Metric and U.S. Customary Units of Measurement," in S.M. Lang and A.M. Orellana, "The Metric System," in *Suggestions to Authors of the Reports of the United States Geological Survey*, Sixth Edition (Washington, DC, 1978), pp. 192-196.

Selected Tables Converted to SI Metric Values

The seven tables listed below contain data converted to equivalent SI units. The crosswalk given below shows the correlation between the tables of SI units and their corresponding tables in U.S. customary units from Chapter 1 of this report. No data tables from the "Photovoltaic Cell and Module Manufacturing Activities" chapter are converted to equivalent SI units.

Appendix E Table Number	Chapter 1 Table Number
E2	Table 1
E3	Table 6
E4	Table 7
E5	Table 9
E6	Table 10
E7	Table 11
E8	Table 12

Table E2. Number of Companies and Annual Shipments of Solar Thermal Collectors, 1974-1993
(Thousand Square Meters)

Year	Number of Companies	Solar Thermal Collector Shipments		
		Total	Import	Export
1974	45	118	NA	NA
1975	131	348	NA	NA
1976	186	539	NA	NA
1977	321	958	NA	NA
1978	340	1,009	37	78
1979	349	1,324	27	79
1980 ^a	233	1,802	22	104
1981 ^a	203	1,870	18	72
1982 ^a	265	1,730	39	42
1983 ^a	203	1,563	47	15
1984	225	1,597	58	32
1985	NA	NA	NA	NA
1986	98	870	44	21
1987	59	675	64	17
1988	51	759	76	15
1989	44	1,067	115	43
1990	51	1,060	145	23
1991	48	611	143	31
1992	45	658	153	29
1993	41	647	189	38

^a Includes imputation of shipment data to account for nonrespondents.

NA= Not available. The data for 1985 are incomplete.

Note: Total Shipments include import and export shipments.

Sources: 1974-1977: Federal Energy Administration telephone survey. 1978-1984: Energy Information Administration, Form EIA-63, "Annual Solar Thermal Collector and Photovoltaic Module Manufacturers Survey." 1982-1993: Energy Information Administration, Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey."

Table E3. Solar Thermal Collector Shipments by Type, 1980-1993
(Thousand Square Meters)

Year	Low-Temperature		Medium-Temperature		High-Temperature ^a
	Shipments	Average Annual Shipments per Manufacturer	Shipments	Average Annual Shipments per Manufacturer	Shipments
1980 ^b	1,136	14.4	666	2.7	NA
1981 ^b	806	10.7	2	4.1	NA
1982 ^b	695	11.4	1,035	4.2	NA
1983 ^b	451	8.2	1,113	6.2	NA
1984	416	8.7	1,109	5.4	72
1985	NA	--	NA	--	NA
1986	348	15.8	103	1.2	418
1987	293	24.4	89	1.8	293
1988	309	38.6	68	1.5	382
1989	398	39.8	185	5.1	484
1990	339	28.2	235	5.7	787
1991	519	32.4	92	2.2	(^c)
1992	575	35.9	83	2.5	(^c)
1993	560	43.1	86	2.6	1

^aFor high temperature collectors, average annual shipments per manufacturer are not disclosed

^bIncludes data imputed from nonrespondents

^cData for 1985 are incomplete

(^c) = Less than 500 square meters.

-- = Not applicable.

NA = Not available. The data are incomplete.

Note: Totals may not equal sum of components due to independent rounding.

Sources: 1980-1984: Energy Information Administration, Form EIA-63, "Annual Solar Thermal Collector and Photovoltaic Module Manufacturers Survey." 1985-1993: Energy Information Administration, Form CE-83A, "Annual Solar Thermal Collector Manufacturers Survey."

Table E4. Shipments by the Top Five Solar Thermal Collector Manufacturing States/Territories 1992 and 1993
(Thousand Square Meters)

Origin	Shipments ^a		Percentage	
	1992	1993	1992	1993
California	277	193	55	42
Florida . .	19	18	4	4
Other ^b . . .	199	238	39	52
Subtotal	496	449	98	98
Total . . .	505	458	100	100

^a Includes domestic shipments and exports.

^b Other includes New York, New Jersey, and Puerto Rico.

Note: Totals may not equal sum of components due to independent rounding.

Source: Energy Information Administration, Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey."

Table E5. Solar Thermal Collector Shipment by Type, Quantity, Value and Average Price, 1992 and 1993

Type	1992			1993		
	Quantity (thousand square meters)	Value (thousand dollars)	Average Price (dollars per square meter)	Quantity (thousand square meters)	Value (thousand dollars)	Average Price (dollars per square meter)
Low -Temperature						
Liquid and Air	575	15,403	26.80	560	16,819	30.05
Medium-Temperature						
Air	(*)	8	124.59	(*)	7	109.65
Liquid						
ICS/Thermosiphon	28	3,825	136.08	28	4,446	157.42
Flat Plate	54	5,441	100.31	58	5,887	101.66
EvacuatedTube	W	W	W	(*)	174	(*)
Concentrator	W	W	W	(*)	9	(*)
All Medium -Temperature	83	9,831	117.95	86	10,523	121.69
High -Temperature						
Parabolic Dish and Trough . . .	(*)	148	814.95	1	260	237.98
Total	658	25,382	--	647	27,602	42.64

(*) = Less than 500 square meters.

-- = Not applicable.

W = Withheld to avoid disclosure of individual company data.

Note: Totals may not equal sum of components due to independent rounding.

Source: Energy Information Administration, Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey."

Table E6. Shipments of Solar Thermal Collectors by Market and Type, 1992 and 1993
(Thousand Square Meters)

Market Sector	Low-Temperature	Medium-Temperature					High-Temperature	1993 Total	1992 Total
	Liquid/Air	Air	Liquid				Parabolic Dish/Trough		
	Metallic and Nonmetallic		ICS/Thermo-siphon	Flat-Plate (Pumped)	Evacuated Tube	Concentrator			
Residential	543	(¹)	28	51	(¹)	(¹)	(¹)	622	634
Commercial	16	0	(¹)	4	0	0	0	20	19
Industrial	1	0	(¹)	1	0	0	0	3	3
Utility	0	0	(¹)	1	(¹)	0	1	3	2
Other ^a	0	0	(¹)	0	0	0	(¹)	(¹)	1
Total	560	(¹)	28	58	(¹)	(¹)	1	647	658

^aOther includes shipments of solar thermal collectors to other sectors such as government, including the military but excluding space applications.

ICS = Integral Collector Storage.

(¹) = Less than 500 square meters.

Note: Totals may not equal sum of components due to independent rounding.

Source: Energy Information Administration, Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey."

Table E7. Shipments of Solar Thermal Collectors by End Use and Type, 1992 and 1993
(Thousand Square Meters)

End Use	Low-Temperature	Medium-Temperature					High-Temperature	1993 Total	1992 Total
	Liquid/Air	Air	Liquid				Parabolic Dish/Trough		
	Metallic and Nonmetallic		ICS/Thermosiphon	Flat-Plate (Pumped)	Evacuated Tube	Concentrator			
Pool Heating	558	0	0	3	0	0	0	561	577
Hot Water	0	0	28	53	(¹)	(¹)	(¹)	82	74
Space Heating . . .	1	(¹)	(¹)	0	0	0	0	1	3
Space Cooling . . .	0	0	0	0	0	0	0	0	(¹)
Combined Space and Water Heating	0	0	0	(¹)	0	0	0	(¹)	(¹)
Process Heating . .	0	0	(¹)	1	0	0	0	2	3
Electricity Generation	0	0	0	0	0	0	1	1	(¹)
Other ^a	0	0	0	0	0	(¹)	0	(¹)	(¹)
Total	560	(¹)	28	58	(¹)	(¹)	1	647	658

^aOther includes shipments of solar thermal collectors for other uses such as cooking foods, water pumping, water purification, desalinization, distilling, etc.

ICS = Integral Collector Storage.

(¹) = Less than 500 square meters.

Note: Totals may not equal sum of components due to independent rounding.

Source: Energy Information Administration, Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey."

Table E8. Shipments of Solar Thermal Collectors by Destination, 1992 and 1993
(Square Meters)

Destination	Shipments		Destination	Shipments	
	1992	1993		1992	1993
Alabama	174	156	Nebraska	162	156
<u>Alaska</u>	0	0	<u>Nevada</u>	7,285	1,209
Arizona	19,485	26,524	New Hampshire ..	182	171
Arkansas	189	156	New Jersey	6,245	5,660
California	165,119	143,084	New Mexico	831	951
Colorado	4,150	2,194	New York	6,342	6,852
Connecticut	1,071	1,292	North Carolina ...	521	543
Delaware	0	0	North Dakota	0	0
District of Columbia	0	0	Ohio	1,071	1,292
<u>Florida</u>	353,529	343,845	Oklahoma	9	0
Georgia	2,587	3,206	Oregon	7,658	11,384
Hawaii	15,770	18,256	Pennsylvania	2,723	1,637
Idaho	9	21	Puerto Rico	18,821	23,540
Illinois	1,980	2,574	Rhode Island	452	0
Indiana	909	1,167	South Carolina	181	243
Iowa	12	24	South Dakota	0	0
Kansas	177	189	Tennessee	162	167
Kentucky	0	0	Texas	1,750	3,740
Louisiana	162	156	Utah	4	33
Maine	239	2,221	Vermont	181	170
Maryland	1,072	1,323	Virgin Islands (U.S.)	691	272
Massachusetts	1,124	1,161	Virginia	314	195
Michigan	4	314	Washington	2,825	1,195
Minnesota	844	98	West Virginia	15	15
Mississippi	0	0	Wisconsin	1,753	1,421
Missouri	162	313	Wyoming	0	0
Montana	0	10			
Shipments to U.S. States/Territories				628,946	609,121
Exports				29,337	38,227
Total Shipments				658,283	647,348

Notes: •Underlined states sponsored incentives for solar thermal collector purchases during 1992 (Solar Energy Industries Association, *Solar Industry Journal*, First Quarter 1993, pp. 16-21). •States in bold face sponsored incentives during 1993. (Steve Kalland, Solar Energy Industry Association, personal communication to James Holihan, Energy Information Administration, Washington, D.C. (June 1, 1994)).
Source: Energy Information Administration, Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey."

Appendix F

Solar Collector Installed Capacity and Energy Production in the United States

Solar One represented the first generation of solar-power towers and was a pilot plant located near Barstow, California.

Appendix F

Solar Collector Installed Capacity and Energy Production in the United States

Information on the amount of solar collectors, solar thermal, and photovoltaics shipped for installation has been reported in this series of reports, "Solar Collector Manufacturing Activity." Solar thermal collectors are quantified by area (square feet). Photovoltaic cells and modules are quantified by the amount of electrical capacity (peak watts).

Since 1974, approximately 219 million square feet of solar thermal collectors were shipped for eventual installation in the United States (Table F1). Solar thermal collectors are grouped into three categories: low-temperature, medium-temperature, and high-temperature. Presuming an overall efficiency of 50 percent for all three categories and a 1,500 Btu per square foot average daily insolation, the potential thermal energy production from the 219 million square feet of solar thermal collectors is 0.060 quadrillion Btu (quads) in 1992.

An efficiency of 50 percent for solar thermal collectors exposed to 1,500 Btu insolation is a simplified approach for this energy calculation. Low-temperature and high-temperature collectors have been rated at more than 50 percent efficient, and medium-temperature collectors are generally less than 50 percent efficient. A mildly cloudy day produces about 1,500 Btu of insolation onto an area of 1 square foot.

In 1991, U.S. nonutility power producers reported installed capacity of 360 megawatts and gross electricity generation of 746 million kilowatthours (the thermal energy equivalent is 0.008 Quad) from solar thermal collectors.¹⁶ Ninety-eight percent of the installed capacity was SEGS I through IX (nine operating Solar Electric Generating System plants in southern California with an installed capacity of 354 megawatts). A 10th SEGS plant (SEGS X) was never constructed as planned in 1991.

¹⁶Energy Information Administration, *Annual Energy Review* (June 1994), Table 8.12.

Table F1. Annual Photovoltaic and Solar Thermal Domestic Shipments, 1974-1993

Year	Domestic Shipments ^a	
	Photovoltaic (peak kilowatts)	Solar Thermal (thousand square feet)
Total, 1974-1993	69,730	219,028
1993	6,137	6,557
1992	5,760	6,770
1991	6,035	6,242
1990	6,293	11,164
1989	5,462	11,021
1988	4,318	8,016
1987	3,029	7,087
1986	3,224	9,136
1985	4,099	19,166
1984	7,759	16,843
1983	10,717	16,669
1982	6,897	18,166
1981	--	19,362
1980	--	18,283
1979	--	13,396
1978	--	10,020
1977	--	10,312
1976	--	5,801
1975	--	3,743
1974	--	1,274

^aTotal shipments minus export shipments.

E = Estimated data (see Appendix A, pages 24 and 25).

-- = Not applicable.

Sources: 1974-1977: Federal Energy Administration telephone survey. 1978-1984: Energy Information Administration, Form EIA-63, "Annual Solar Thermal Collector and Photovoltaic Module Manufacturers Survey." 1985-1993: Energy Information Administration, Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey," and Form CE-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey."

Table F2. U.S. Utility Net Electricity Generation from Solar Energy, 1993
(Thousand Kilowatthours)

Utility	Plant (State)	Net Generation
Sacramento Municipal Utility District	Solar (California)	2,680
Austin Electric	Decker Creek (Texas)	366
Pacific Gas & Electric . .	PVUSA 1 (California)	748
Virginia Electric Power .	North Anna (Virginia)	8
Total		3,802

Source: Energy Information Administration, *Electric Power Monthly*, April 1994, DOE/EIA-0226(93/04), Table 64.

Since 1982, approximately 70 peak megawatts of photovoltaic cells and modules were shipped for eventual installation in the United States (Table F1). Assuming a 27.5 percent capacity factor,¹⁷ the potential energy production from the 70 peak megawatts is 170 million kilowatthours of electricity. This is equivalent to 0.002 Quad of thermal energy in 1993, using a thermal conversion rate of 10,302 Btu per kilowatthour of electricity generation.¹⁸

In 1993, U.S. electric utilities reported that net electric generation from photovoltaic modules was 3.8 million kilowatthours (Table F2). Net generation is gross generation minus plant use by all electric utility-owned plants.¹⁹

¹⁷Department of Energy, "The Potential of Renewable Energy, An Interlaboratory White Paper" (March 1990), p. G-5.

¹⁸Energy Information Administration, *Annual Energy Review 1993* (June 1994), Table A7.

¹⁹Energy Information Administration, Form EIA-759, "Monthly Power Plant Report."

Estimated U.S. solar electricity generation was 968.8 million kilowatthours in 1992. Overall, estimated solar energy production was 0.07 quadrillion Btu, and adjusted total energy production in the United States was 65.88 quadrillion Btu (Table F3).

Table F3. Estimated U.S. Solar and Total Energy Production, 1993
(Quadrillion Btu)

Activity, Production Sector, and Solar Energy Source	Energy Production
Production to Generate Electricity	
Electric Utilities	
Photovoltaic	(s)
Nonutility Power Producers	
Solar Thermal-Electric	0.01
End Users	
Photovoltaic	(s)
Production to Generate Thermal Energy	
End Users	
Solar Thermal	.06
Estimated Solar Energy Production	0.07
Adjusted Production Estimate	^a65.88

^aAdjusted total is the sum of EIA's preliminary total energy production data of 65.81 quadrillion Btu (*Annual Energy Review 1993*, Table 1.2) and estimated solar energy production data of 0.07 quadrillion Btu.

(s) = Less than 0.005 quadrillion Btu.

Sources: Energy Information Administration (EIA), Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey," and Form CE-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey." EIA, Form EIA-759, "Monthly Power Plant Report." EIA, *Annual Energy Review 1993* (June 1994), Table 1.2 and Table 8.12.

Glossary

University of Michigan's Sunrunner, winner of SUNRAYCE USA, 1990, shown during qualifications at Daytona, Florida.

Glossary

Air Collector: A medium-temperature collector used predominantly in space-heating applications, utilizing pumped air as the heat-transfer medium.

Amorphous Silicon: An alloy of silica and hydrogen, with an irregular internal atomic arrangement, that can be deposited in thin-film layers (a few micrometers in thickness) by means of a number of deposition methods to produce thin-film photovoltaic cells on glass, metal, or plastic substrates.

Btu (British Thermal Unit): A standard unit for measuring the quantity of heat energy equal to the quantity of heat required to raise the temperature of 1 pound of water by 1 degree Fahrenheit.

Cast Silicon: Crystalline silicon obtained by pouring pure molten silicon into a vertical mold and adjusting the temperature gradient along the mold volume during cooling to obtain slow, vertically advancing crystallization of the silicon. The polycrystalline ingot thus formed is composed of large, relatively parallel, interlocking crystals. The cast ingots are sawed into wafers for further fabrication into photovoltaic cells. Cast-silicon wafers and ribbon-silicon sheets fabricated into cells are usually referred to as polycrystalline photovoltaic cells.

Concentrator: A reflective or refractive device that focuses incident insolation onto an area smaller than the reflective or refractive surface, resulting in increased insolation at the point of focus.

Consumer Goods: Goods such as calculators, computers, toys, and watches that are powered by photovoltaic cells and modules.

Evacuated-Tube Collector: A solar thermal collector in which the collector fluid flows through an absorber tube that is contained inside an evacuated glass cylinder.

Export (solar): A shipment of solar thermal collectors and/or photovoltaic devices sent from the United States and any of its territories to a foreign country.

Flat-Plate (pumped): Medium-temperature solar thermal collector, typically with a metal frame, glazing, absorbers (usually metal), and insulation, that uses pumped liquid as the heat-transfer medium; predominately used in water-heating applications.

Generation (electricity): The process of producing electrical energy by transforming other forms of energy; also, the amount of electrical energy produced, expressed in watthours (Wh).

Gross Generation: The total amount of electric energy produced by the generating units at a generating station or stations, measured at the generator terminals.

High-Temperature Collector: A solar thermal collector that generally operates at temperatures above 180 degrees Fahrenheit.

Import (solar): A shipment of solar thermal collectors and/or photovoltaic devices into the United States and any of its territories from foreign countries.

Integral Collector Storage (ICS): A solar thermal collector in which incident solar radiation is absorbed directly by the storage medium.

Kilowatthour (kWh): One thousand watthours.

Liquid Collector: A medium-temperature solar thermal collector, employed predominantly in water heating, which uses pumped liquid as the heat-transfer medium.

Low-Temperature Collector: A solar thermal collector that generally operates at temperatures below 110 degrees Fahrenheit.

Medium-Temperature Collector: A solar-thermal collector that generally operates in the temperature range of 140 degrees Fahrenheit to 180 degrees Fahrenheit but can also operate at temperatures as low as 110 degrees Fahrenheit.

Net Generation: Gross generation less the electric energy consumed at the generating station for station use.

One Sun: Natural solar insolation falling on an object without concentration or diffusion of the solar rays.

Original Equipment Manufacturer (OEM): A non-photovoltaic manufacturer that combines photovoltaic technology into existing or newly developed product lines.

Parabolic Dish: A high-temperature (above 180 degrees Fahrenheit) solar thermal concentrator, generally bowl-shaped, with two-axis tracking.

Parabolic Trough: A high-temperature (above 180 degrees Fahrenheit) solar thermal concentrator with the capacity for tracking the sun using one axis of rotation.

Peak Kilowatt: One thousand peak watts.

Peak Megawatt: One million peak watts.

Peak Watt: A manufacturer's unit indicating the amount of power a photovoltaic cell or module will produce at standard test conditions (normally 1,000 watts per square meter and 25 degrees Celsius).

Person Years: The number of hours worked during the year by all persons in the identified type of work divided by the number of hours worked during the year (2080).

Photovoltaic Cell: An electronic device consisting of layers of semiconductor materials fabricated to form a junction (adjacent layers of materials with different electronic characteristics) and electrical contacts, and being capable of converting incident light directly into electricity (direct current).

Photovoltaic Module: An integrated assembly of interconnected photovoltaic cells designed to deliver a selected level of working voltage and current at its output terminals, packaged for protection against environmental degradation, and suited for incorporation in photovoltaic power systems.

Ribbon Silicon: Sheets of crystalline silicon fabricated by a variety of solidification (crystallization) methods

whereby thin silicon sheets are withdrawn from a pool of relatively pure molten silicon. The methods include: edge-defined, film-fed growth (EFG) and dendritic-web growth.

Single-Crystal Silicon: An extremely pure form of crystalline silicon produced by dipping a single crystal seed into a pool of molten silicon under high vacuum conditions and slowly withdrawing a solidifying single crystal boule (rod) of silicon. The boule is sawed into thin silicon wafers and fabricated into single-crystal photovoltaic cells.

Solar Thermal Collector: A device designed to receive solar insolation and convert it into thermal energy. Normally, a solar thermal collector includes a frame, glazing, and an absorber, together with appropriate insulation. The heat collected by the solar thermal collector may be used immediately or stored for later use.

Special Collector: An evacuated tube collector or a concentrating (focusing) collector. Special collectors operate in the temperature range from just above ambient temperature (low concentration for pool heating) to several hundred degrees Fahrenheit (high concentration for air conditioning and specialized industrial processes).

Survey Frame: The list of companies to which survey forms are sent.

Thermosiphon System: A solar collector system for water heating in which circulation of the collection fluid through the storage loop is provided solely by the temperature and density difference between the hot and cold fluids.

Value (of Shipments): The value received for the complete systems at the company's net billing price, freight- on-board factory, including charges for cooperative advertising and warranties. This does not include excise taxes, freight or transportation charges, or installation charges.

Watthour (Wh): An electrical energy unit of measure equal to 1 watt of power supplied to, or taken from, an electric circuit steadily for 1 hour.

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