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CO-OPERATIVE PROGRAMME ON PHOTOVOLTAIC POWER SYSTEMS

Task 1
Exchange and Dissemination of Information on PV Power Systems

National Survey Report of PV Power Applications in THE UNITED STATES *2003*

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1. *Executive Summary*

Photovoltaic Activities In The United States

The United States Photovoltaic Program made progress in the areas of increased installations, component R&D, systems standardization and reduction of barriers that translates to improved acceptance of photovoltaic systems in 2003. The following is a summary of that progress as categorized by production, installations, development and commercialization of product.

Production

United States cell/ module production totaled 103.02 MW in 2003, which was a 20 % decrease from a similar period in 2002. The decrease was driven by the difficult year experienced by AstroPower prior to bankruptcy and the reduced production by BP Solar caused by the production by new plants in Asia and Europe and changes at the US BP Solarex plant related to larger slices and a new anti-reflection coating. The production by manufacturers is shown in Figure E1.

Figure E1: US Photovoltaic Cell/Module Production

Company	1996	1997	1998	1999	2000	2001	2002	2003
Shell Solar	17.00	22.00	20.00	22.20	28.00	39.00	46.50	52.00
BP Solarex	10.80	14.80	15.90	18.00	20.47	25.22	31.00	13.42
Solec International	3.50	4.00	4.00	0.60	0.00	0.00	0.00	0.00
AstroPower	2.85	4.30	7.00	12.00	18.00	26.0	29.70	17.00
USSC	0.60	1.70	2.20	3.00	3.00	3.80	4.00	7.00
RWE Schott (ASE)	3.00	4.00	4.00	4.00	4.00	5.00	5.00	4.00
Evergreen Solar							1.9	2.80
First Solar							1.0	3.00
Global Solar								2.00
Other*	1.10	0.20	0.60	1.00	1.50	1.30	2.50	1.80
TOTAL	**38.85**	**51.00**	**53.70**	**60.80**	**74.97**	**100.32**	**120.60**	**103.02**

From PV News, Vol 23, No 3, Mar 2004.
*SunPower, Amonix, Iowa Thin Films, etc.

Progress in Thin-film Commercialization

The United Solar Systems Corporation (USSC) 30-MW roll-to-roll amorphous silicon plant produced 7 MW in 2003. The BP Solar amorphous silicon factory in Virginia and its CdTe

factory in California, which were closed in late 2002, had zero production. Shell Solar (formerly Siemens Solar Industries) shipped nearly 3 MW of copper-indium-diselenide (CIS) photovoltaic modules. First Solar shipped 3 MW of cadmium telluride (CdTe) modules and announced plans to produce 6 MW in 2004. Global Solar produced nearly 2 MW of CIS on steel modules. Iowa Thin Film Technologies produced about 100 kilowatts for specialty small power applications.

United States PV Installations

Despite the reduced production, the United States installations increased by 42 percent from 44.4 MW (not counting systems sized less than 40 watts) in 2002 to 63 megawatts in 2003. Most of the growth was in the grid-connected sector-from 23 MW in 2002 to 38 MW in 2003.

Figure E 2 shows the annual distribution of the US applications by market sector.

E 2: Photovoltaic Applications by Market Sector in The United States

APPLICATION	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Grid-connected Distributed	1.2	1.5	2.0	2.0	2.2	3.7	5.5	12.0	22.0	32.0
Off-grid Consumer	3.0	3.5	4.0	4.2	4.5	5.5	6.0	7.0	8.4	9.0
Government Projects	0.6	0.8	1.2	1.5	1.5	2.5	2.5	1.0	1.0	1.0
Off-grid Industrial/ Commercial	3.3	4.0	4.4	4.8	5.2	6.5	7.5	9.0	13.0	16.0
Consumer (<40 W)	1.7	2.0	2.2	2.2	2.4	2.4	2.5	3.0	4.0	4.0
Central Station	—	—	—	—	—	—	—	—	—	5.0
Total Installed in USA	9.4	10.8	13.8	14.7	15.8	21.0	24.0	32.0	48.4	67.0
IMPORTS						2.0	4.0	5.0	9.0	18.0
EXPORTS	16.2	24.0	25.1	36.3	37.9	39.8	55.0	73.3	81.2	54.0
TOTAL PRODUCED	**25.6**	**34.8**	**38.9**	**51.0**	**53.7**	**60.8**	**75.0**	**100.3**	**120.0**	**103.**

Installation of photovoltaic systems in California nearly doubled to 27 MW in 2003**.** The California PV program involved several key players and unique assistance. The California photovoltaic "buy down" program resulted in the installation of 12.3 MW of grid-connected residential and commercial photovoltaic systems.

The Sacramento Municipal Utility District (SMUD) completed phase two of its "PV Pioneer" program by offering subsidized photovoltaic systems to its customers at reduced prices. SMUD installed about 400 kW of photovoltaic systems in 2003. More than 11 MW of PV systems have been installed by SMUD in the last ten years.

The Los Angeles Department of Water and Power (LADWP) PV program (with subsidies as high as $5.50/W) yielded 3.8 MW of newly installed photovoltaic systems in 2003. Cumulative installations by LADWP reached 7.5 MW.

The California Public Utilities Renewable Portfolio Standard (RPS) Program with Pacific Gas & Electric, Southern California Edison, San Diego Gas and Electric, and Southern California Gas Co. resulted in 9.9 MW installed in 2003.

Other California Utilities and Cities installed nearly 400 kW.

Costs & Prices

The installed cost of grid-connected PV systems decreased slightly as the cash subsidies, especially in California, decreased from $4.50/ACW installed to $3.50/W. In this competitive environment the installed prices dropped from $8.00-$9.00/W peak (AC) to about $7.00/W as shown in Table E3. Some volume systems, primarily installed by builders, were sold at some low prices of $6.50/W. These price reductions were made possible by continued low factory module prices for volume purchases (Table E4) and reduced labor costs owing to increased volume of installations.

Table E-3: Typical Module Prices $US (SINGLE & MULTICRYSTAL SILICON).

YEAR	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
PRICE $/W	4.25	4.25	4.00	3.75	4.00	4.15	4.00	3.50	3.75	3.50	3.25	3.00

*Estimated by PV Energy Systems

Table E-4: National Trends in System Prices for Grid-connected Residential Systems.

YEAR	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
PRICE $/W	12	12	12	11-12	10-12	10-12	10-11	9-11	8-10	7-9	6.5-9	6.5-8.0

*Estimated by PV Energy Systems

Budgets for PV

The federal budget for PV was essentially flat. Table E5 and E6 show the total funds for FY2003 as $73.7 million. About $66 million was approved for research, development and engineering. Market support programs totaled $8 million. The emphasis was placed on R&D with minimal funds for Market stimulation. Nearly one-half of the funds for Market were grants ($100,000 each in support of state Million Solar Roofs program. The propose Federal 15% tax-incentive for grid-connected residential systems was not funded by the Congress.

State tax credits for PV systems totaled over $200 million and the funds are expected to increase. Nearly 60% of the state support came from California, which installed nearly 80% of the grid-connected systems in 2003.

Table E5. Public Budgets for R&D, Demonstration and Market Incentives ($US)

UNITED STATES FY2003 ($US) October 2002-September 2003	R&D	Demo	Market	Total
National/Federal	$65.7 M	--------	$8.00 M	$73.7 M
State/Regional	NA	NA	$200 M/year estimated	$200 M estimated
Total	**$65.7 M**	**0**	**$8.0 M + $200M for states**	**$73.7 M + $200 M for states**

Table E6. United States' DOE Federal Funding Schedule for Photovoltaics

PROGRAM ELEMENT	FY 2001	FY 2002	FY 2003
Fundamental Research	$17.560 M	$21.700 M	$30.400 M
Advanced Materials & Devices	$37.000 M	$26.900 M	$29.793 M
Technology Development	$19.700 M	$17.555 M	$13.500 M
TOTAL	**$74.260 M**	**$66.155 M**	**$73.693 M**

2 The Implementation Of PV Systems

The PV power system market is defined as the market of all nationally installed PV applications with a PV capacity of 40 W or more. A PV system consists of modules, inverters, optional batteries and all installation and control components for modules, inverters and batteries.

2.1 Applications for Photovoltaics in the United States

The United States photovoltaic applications over 40 W grew 42% from 44.4 MW in 2002 to 63 MW in 2003. The United States applications for photovoltaics cover virtually all application sectors. Figure 1 shows a summary of the development of the applications sectors. The grid-connected applications started its high growth rate with the State-subsidized applications.

The Off-grid Consumer Sector:

This sector includes applications in mostly remote habitat. They include photovoltaics for remote residences, boats, motor homes, travel trailers, vacation cottages, and farms. The systems provide electricity for all types of loads used for modern habitat. Most systems are rated less than 1 kW, have several days of battery storage, and usually serve dc loads. Larger systems use stand-alone inverters to power ac loads and may have a diesel generator as backup. Over 9.0 MW was installed in the off-grid consumer sector in the United States in 2003.

The Off-grid Commercial/Industrial Sector:

This sector is the second largest sector of the United States photovoltaic market (16.0 MW in 2003). Telecommunication applications encompasses a wide range of applications from remote repeaters and amplifiers for all modes of communication including fiber optics, satellite links, and cable links to small data link stations via phone, TV, and secure communications throughout the country. Remote photovoltaic power systems also serve as sensor power sources and data communication power for a broad range of applications, including; weather, storm warning,

seismic, radiation monitors, pollution monitors, security phones on highways and parking lots, and traffic monitors. Remote lighting and signals are proliferating with applications ranging from bus stops, remote shelters, parking lot lights, billboards, highway information/construction signs (replacing small engine generators), inter-coastal navigation aides and lighting for environmentally friendly corporate headquarters.

The Government Sector:

Photovoltaics systems serve a broad array of applications in this sector and many applications are considered "emerging markets". These include photovoltaic/diesel hybrid power stations that can ultimately serve remote sites or be transportable power for emergency power. The Department of Defense funds the installation of about 0.5 MW per year that has resulted in installed photovoltaic systems totaling over 3 MW. These photovoltaic systems resided in applications ranging from remote sensors, to large off-grid photovoltaic-diesel hybrid systems where utility power is not available or reliable.

The recent Utility Photovoltaic Group (UPVG) program has also directed thousands of utility installations amounting to over 9 MW in five years. Several thousand applications have been installed that are "nearly economic" applications. The United States Department of Energy has subsidized these early applications with an average of 25% of federal funds. No UPVG systems were installed in 2003. Another important government program is "Photovoltaics for Schools" where Federal and State programs funded the installation of small grid-connected systems in schools for education and emergency power.

The On-Grid Distributed Sector:

Prior to 1999, this sector involved a few "early adopters" that installed residential and commercial systems connected to the utility grid and amounted to less than 2 MW/year. In 2003 this sector nearly doubled, compared to the 2002 installations, to 32 MW of new installations. Photovoltaic installation growth was primarily in the "On-grid Residential' sector and was primarily the result of the tax credits implemented by several States. California led the way with over 27 MW of grid- connected systems installed in 2003.

The State of California PV program involved several key players and unique assistance programs:

a) The California photovoltaic "buy down" program resulted in the installation of 12.3 MW of grid-connected residential and commercial grid-connected photovoltaic systems.
b) The Sacramento Municipal Utility District (SMUD) completed phase two of its "PV Pioneer" program by offering subsidized photovoltaic systems to its customers at reduced prices. SMUD installed about 400 kW of photovoltaic systems in 2003. Over 11 MW of PV systems have been installed by SMUD in the last ten years.
c) The Los Angeles Department of Water and Power (LADWP) PV program (with subsidies as high as $5.50/W) resulted in 3.8 MW of newly installed photovoltaic systems. Cumulative installations by LADWP reached 7.5 MW.

d) The California Public Utilities RPS program with Pacific Gas & Electric, Southern California Edison, San Diego Gas and Electric, and Southern California Gas Co. resulted in 9.9 MW installed in 2003.
e) Other Utilities and Cities installed nearly 400 kW.

Table 1. Photovoltaic Applications by Market Sector in The United States by IEA-defined Sub-markets**

APPLICATION	1996	1997	1998	1999	2000	2001	2002	2003
Grid-connected Distributed	2.0	2.0	2.2	3.7	5.5	12.0	22.0	32.0
Off-grid Consumer	4.0	4.2	4.5	5.5	6.0	7.0	8.4	9.0
Government Projects	1.2	1.5	1.5	2.5	2.5	1.0	1.0	1.0
Off-grid Industrial/ Commercial	4.4	4.8	5.2	6.5	7.5	9.0	13.0	16.0
Consumer (<40 W)*	2.2	2.2	2.4	2.4	2.5	3.0	4.0	4.0
Central Station	—	—	—	—	—	—	—	5.0
Total Installed in USA	13.8	14.7	15.8	21.0	24.0	32.0	48.4	67.0
IMPORTS				2.0	4.0	5.0	9.0	18.0
EXPORTS	25.1	36.3	37.9	39.8	55.0	73.3	81.2	54.0
TOTAL PRODUCED	**38.9**	**51.0**	**53.7**	**60.8**	**75.0**	**100.3**	**120.6**	**103.0**

** IEA sub-markets are categorised for photovoltaic power applications above 40 watts.

Other important programs included but were not limited to:

- The United States PV for Schools program installed photovoltaic systems on schools with a goal of increasing awareness of photovoltaic applications among youngsters.
- The State programs for renewable energy set-asides resulting from restructuring.

Other Forms of Marketing Incentives:

Other forms of marketing incentives included:

- Standard photovoltaic systems for new homes offered through homebuilders by AstroPower, BP Solarex and Shell Solar.
- Expanded in-store sales of packaged retrofit, grid-connected, AstroPower photovoltaic systems through Home Depot stores.

2.1 Photovoltaic Applications by Market Sector in The United States

The Cumulative Photovoltaic Installations by Market Sector in The United States are listed in Table 2.

Table 2. The Cumulative Installed Photovoltaic Power in the United States by IEA-defined Sub-markets**

Sub-market/ Application	31/12/ 1994	31/12/ 1995	31/12/ 1996	31/12/ 1997	31/12/ 1998	31/12/ 1999	31/12/ 2000	31/12/ 2001	31/12/ 2002	31/12/ 2003

	MWp	MWp	MWp	MWp	MWp	MWp	MWp	MWp	MWp	MWp
Off-grid Domestic	15.8	19.3	23.3	27.5	32.0	37.5	43.5	50.5	58.9	67.9
Off-grid Non-Domestic	21.8	25.8	30.2	35.0	40.2	46.7	55.2	64.7	77.7	93.7
On-grid Distributed	8.2	9.7	11.0	13.7	15.9	21.1	28.1	40.6	63.6	95.6
On-grid Centralised	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	18.0
TOTAL	**57.8**	**66.8**	**76.5**	**88.2**	**100.1**	**117.3**	**138.8**	**167.8**	**212.2**	**275.2**

** IEA sub-markets are categorised for photovoltaic power applications above 40 watts.

2.2 Major Projects, Demonstration and Field Test Programmes

The major photovoltaic projects in the United States consisted of new initiatives and the continuation of some projects started in the 1995-1999 time frames. These included:

- Pioneer II, where SMUD offers photovoltaic systems for sale to customers at subsidized prices (as low as $3.50/W installed. The Pioneer II program called for 5 MW of photovoltaics to be installed in 1999-2004. SMUD installed 1.2 MW in 1999, 1.4 MW in 2000, 1.7 MW in 2001, 1.4 MW in 2002 and 0.4 MW in 2003. The program is essentially complete with over 11.3 MW installed since its inception.

- A program initiated by the state of California where cash rebates of $4.50/W were offered to residential and commercial customers that installed grid-connected photovoltaic systems on investor-owned utility grids (1.4-1.6 MW in 2001, 8.1 MW in 2002, and 12.3 MW in 2003). Cumulative installations of nearly 27 MW have been made. California has a program of Renewable Power Set-asides administered by the California Public Utilities Commission. Over 9.9 MW were installed by the four key utilities- Pacific Gas and Electric, Southern California Edison, San Diego Gas and Electric, and Southern California Gas Company. Ten cities in California installed 0.4 MW of PV. The total PV installed by California was 25.8 MW with cumulative installations of 69.8 MW.

- State Photovoltaic Assistance Programs: Although detailed figures are not available for most State programs, several states have renewable energy subsidies. These are funds for research leading to new photovoltaic industry within the state, assistance for photovoltaic school programs, tax rebates, Renewable Portfolio Standards and “Green Pricing” programs. Major programs include:

Arizona: Over 50 MW of photovoltaic systems has been installed during the last ten years. Over 4 MW of photovoltaic Systems have been installed in 2002-2003.

California: Over $250 M has been invested in grid-connected Photovoltaic electricity generation systems.

Illinois: Led by the strong "Brightfields" program in Chicago (where abandoned factories (Brownfields) are converted to photovoltaic manufacturing plants (owned and operated by Spire Corporation) or installed photovoltaic systems. The state of Illinois passed the largest subsidy in the United States for photovoltaic systems, $6.00/W_p$. Over 1 MW of photovoltaic systems was installed in Illinois in 2003.

Ohio: A primary objective in Ohio is support for 50 schools to have photovoltaic systems/training modules installed on public schools.

New Jersey: New Jersey is implementing one of the most aggressive PV support programs in the United States. Over $100 million has been appropriated for the program.

New York: New York has legislated over $100 M to support new industry, new installations, and studies to accelerate commercialization of photovoltaics. Recently (May 2002) New York increased the photovoltaic subsidy to $5.00/W for grid-connected systems.

North Carolina: North Carolina provides a 35% tax credit for photovoltaic system installations.

Table 3. Summary of New Initiatives Major Projects, Political Environment, Utility Regulation, Tax Incentives, and New Product Strategies

Project Date Plant Start Up	Technical Data/Economic Data	Objectives	Main Accomplishments Until the End of 2003 Problems and Lessons Learned	Funding	Project Management	Remarks
Sacramento Municipal Utility District PV Pioneer II (1998-2004) **Residential, Commercial Systems**	Pioneer II: (1-3 kW) PV grid-connected, roof mounted. A $3/W effective subsidy to allow less than $3.50/W cost to the customer.	Provide customers with grid-connected PV systems. Evaluate the performance of the components and the systems. Test the impact of ten years of volume purchase on the installed cost to lead to fully economic PV for homes.	New models of inverters are much improved. A $2.40/W subsidized system price has led to applicants exceeding program plans. Installed nearly 1.4 MW in residences and commercial, municipal buildings in 2002.and 0.4 MW in 2003. Over 6 MW were installed under Pioneer II.	SMUD Utility Comp-any @ 100%	SMUD	Minimal monitoring. SMUD issued long-term contracts for modules and inverters that reduce installed costs from $6.00/W in 1998 to less than $4.00/W in 2002/2003. SMUD has assisted several other utilities in system designs, procurement The program was reported as essentially complete with all objectives met.

California "Buy-down" Program	Residential: Grid-connected. 1-3 kW size. $4.50/W subsidy Decreasing to $3.00/W Watt. 12.4 MW in 2003. Over $50 M in 2003. Commercial Grid-connected. 10-100 kW	To expand renewable energy use as a result of utility restructuring.	Codes, permitting, application process streamlined. Improved industry infrastructure, including offers by new homebuilders, has led to improved communication to consumers and lower installed prices.	State of Cali-fornia	Mainly private utilities and the PV industry	After-subsidy prices appeal to affluent "early adopters" and to business with federal investment tax credits. All California assistance has resulted in 70 MW of PV installations.

2.3 Highlights of R&D

The United States Department of Energy is the principle source of funding for photovoltaics research and development. The DOE photovoltaic budget summarizes the photovoltaic R&D program as follows; "Research is focused on increasing domestic capacity by lowering the cost of delivered electricity and improving the efficiency of modules and systems. Fundamental research at universities was increased to develop non-conventional, breakthrough technologies. Laboratory and university researchers work with industry on large volume, low cost manufacturing, such as increasing deposition rates to grow thin-film layers faster, improving materials utilization to reduce cost, and improving in-line monitoring to increase yield and performance. Specific goals by 2006 are to:

a) Reduce the direct manufacturing cost of photovoltaic modules by 30 percent from the current average manufacturing cost of $ 2.50/W to $1.75/W

b) Identify and begin prototype development of two new leapfrog technologies that have the potential for dramatic cost reduction

c) Establish greater than 20-year lifetime for photovoltaic systems by improving the reliability of balance-of-system components and reduce recurring costs by 40 percent

d) Work with the U.S. photovoltaic industry to facilitate achievement of its roadmap goals of 1-gigawatt cumulative U.S. sales (Export and Domestic) by 2006 and 30 GW by 2020

e) Installed price goals for a grid-connected photovoltaic system paid by an end user (including operation and maintenance costs) are as follows. Price goals are to reduce from a minimum

value of \$6.25/W in 2003 to \$4.50/W_p in 2006 (equivalent to reducing the cost from \$0.25/kWh to \$0.18/kWh.

2.4 Public Budgets For Market Stimulation, Demonstration / Field Test Programs and R&D

The federal budget for PV was essentially flat. Tables 4 and 5 show the total funds for FY 2003 were \$73.7 million. About \$66 million was approved for research, development and engineering. Market support programs totaled \$8 million. The emphasis was placed on R&D with minimal funds for Market stimulation. Nearly one-half of the funds for Market were grants (\$100,000 each in support of state Million Solar Roofs program. Congress did not approve funding for the Federal 15% tax-incentive plan for grid-connected residential systems in 2003.

State tax credits for PV systems totaled over \$200 million and the funds are expected to increase. Nearly 60% of the state support came from California, which installed nearly 80% of the grid-connected systems in 2003.

Table 4. Public Budgets for R&D, Demonstration and Market Incentives (\$US)

UNITED STATES FY2003 (\$US) October 2002-September 2003	R&D	Demo	Market	Total
National/Federal	\$65.7 M	--------	\$8.00 M	\$73.7 M
State/Regional	NA	NA	\$200 M/year estimated	\$200 M estimated
Total	\$65.7 M	0	\$8.0 M +\$200M for states	\$73.7 M +\$200 M for states

Table 5. United States DOE Federal Funding Schedule for Photovoltaics

PROGRAM ELEMENT	FY 2001	FY 2002	FY 2003
Fundamental Research	\$17.560 M	\$21.700 M	\$30.400 M
Advanced Materials & Devices	\$37.000 M	\$26.900 M	\$29.793 M
Technology Development	\$19.700 M	\$17.555 M	\$13.500 M
Southwest Resource Opportunity	0	\$ 0.489 M	
Navajo Electrification Project	0	\$ 2.313 M	\$3.000 M
TOTAL	\$74.260 M	\$71.551 M	\$73.693 M

3 Industry and Growth

3.1 Production of Feedstocks and Wafers

Table 3 shows the United States production of feedstocks (Poly-crystal silicon, single-crystal silicon, EFG wafers and solar grade silicon feed stock. Most of the solar grade silicon feedstock (90 percent) is purchased from the semiconductor industry as scrap.

Table 6. Production/Production Capacity Information for 2003 Feedstock Producers and Wafer Manufacturers

Manufacturer	Process & Technology	Total Production (Ton(t) or MW)	Maximum Production Capacity (t/yr or MW/yr)	Product Destination
BP Solarex	Cast Ingot (Poly-silicon)	50 MW	55 MW	To BP Solar Cell producers
Shell Solar (Siemens).	Single-crystal (Si)	50 MW	55 MW	To Shell Solar producers
RWE Schott	EFG Ribbon Wafers (Si)	35 MW	40 MW	To RWE Schott producers
Evergreen Solar	String Ribbon (Si)	3 MW	4 MW	Internal
Solec	Single Crystal (Si)	20 MW	20 MW	To Sanyo for HIT
Solar Grade Silicon Corp.	Ingot (Si)	Pilot (<100 tons)	Goal = 1000 tons	To slice producers

3.2 Production of Photovoltaic Cells and Modules

Total production of photovoltaic cells and modules in the US decreased by 20 percent from 2002 to 2003. The decrease was caused by decreased production by AstroPower as it went through bankruptcy and by the decreased production of the BP Solarex operation. BP Solarex production decreased because of retooling and process changes, and the dramatic increase in the production of BP Solar factories in Spain.

Table 7. Production/Production Capacity Information For 2003 For Each Manufacturer

Cell/Module Manufacturer	Technology (SC-Si, MC-Si, a-Si, or CdTe)	Total Production (MW)		Maximum Production Capacity (MW/yr)	
		Cell	Module	Cell	Module
Shell Solar	SC-Si	49.00	20.00	55.00	30.00
BP Solar	MC-Si	13.42	13.00	25.00	25.00
AstroPower	SC-Si	17.00	15.00	25.00	25.00
RWE Schott	MC-Si (ribbon)	4.00	4.00	5.00	5.00
Evergreen Solar	MC-Si (ribbon)	2.80	2.80	4.00	4.00
Sunpower	SC-Si	0.60	0.60	1.00	1.00
Thin-film Manufacturers					
USSC	a-Si	7.00	7.00	30.00	20.00
Shell Solar	CIS	3.00	3.00	5.00	5.00
First Solar	CdTe	3.00	3.00	4.00	4.00
Iowa Thin Film Technologies	a-Si	0.10	0.10	Pilot	Pilot
Global Solar	CIS on steel	2.00	2.00	2.0+	2.0+
Other Products/ Concentrators					
Amonix	Single-crystal Si Cells	0.70	0.70	1.00	1.00
TOTALS		**103.00**	**75.00**	**152.00**	**117.00**

Shell Solar (USA-Formerly Siemens Solar Industries):

USA photovoltaics production is fully integrated. Shell Solar purchases "solar grade" poly-silicon to be used in a melt from which single-crystal silicon ingots are pulled using the latest 6-

to 8-inch diameter pullers. Shell Solar then slices the ingots into 300-micron thick wafers using wire saws. The crystal and wafer production is in its plant in the state of Washington. The wafers are processed into cells and modules in an automated plant in Camarillo, CA. Shell Solar modules are certified to all standards including IEEE, ISPRA, and UL. The Shell Solar package is tempered glass/cells/EVA encapsulation/back cover of Tedlar or aluminum. Shell Solar offers a module warranty of 25 years. In 2003 Shell Solar produced over 52 MW of cells and modules. Single-crystal silicon amounted to 49 MW and 3 MW was copper-indium-diselenide thin-film modules.

Shell Solar has performed research, pilot production and testing on copper-indium-diselenide (CIS) solar modules for over fifteen years. CIS modules with efficiencies greater than 12% have been produced. The CIS product was produced in pilot quantities in 1998,1999 and 2000. Shell Solar shipped 3 MW of CIS modules in 2003.

3.2.2 BP Solar (BP Solarex in the United States):

BP/Solar (Solarex) is the world's third largest producer of cast-ingot multi-crystal silicon cells and modules (Kyocera of Japan is first and Sharp of Japan is second). Production in 2003 was reduced in the United States, according to BP SOLAR, owing to production changes for a new antireflection coating and the introduction of a larger (15 cm by 15 cm) cell. New plants in Spain and India permitted BP Solar to serve markets in Europe and Asia directly. BP Solarex purchases "solar grade" poly-silicon, and casts the silicon into rectangular parallelepiped ingots. The ingots are sawed into smaller ingots (15 cm by 15 cm), which are then sliced, using wire saws and ID saws, into 300-micron slices. The slices are processed into solar cells and then integrated into glass/EVA/Cells/EVA/Tedlar modules. BP Solar offers power modules with power outputs of 33 - 300 W. A standard 25-year warranty is offered.

BP Solarex has researched amorphous silicon for over fifteen years and has produced pilot quantities of 5- and 10-W modules (500 kW) for over ten years. Solarex built a 10-MW double-junction amorphous silicon plant in James City County, Virginia. The completed plant underwent final pre-production trials in 1997. First product from the new plant was shipped in 1997. Seven MW of amorphous silicon power modules were produced in 2002. BP Solar terminated amorphous silicon production late in 2002. After attempts to find a buyer for the plant, it was permanently dismantled. BP Solar also closed the California CdTe pilot plant in 2002. No amorphous silicon or cadmium telluride was produced in 2003. We do not expect increased production in the United States beyond the US demand. The present plant, after new processes are complete can produce nearly 25 MW of cells and modules. Whether this occurs will depend on BP Solar "product rationalization" policy.

3.2.3 AstroPower:

AstroPower produced single-crystal cells and modules from purchased reject wafers from the semiconductor industry. AstroPower processed the wafers and produces solar cells using standard processing. Much of the AstroPower product is sold as cells primarily for European building-integrated photovoltaic products. Standard power modules are also produced. All modules are UL listed, and certified by ISPRA or the Arizona State University Photovoltaic Testing Laboratory. AstroPower produced an estimated 17 MW of single crystal silicon cells and

modules in 2003. Shipments were drastically reduced in 2003 because of the financial conditions, which led to the bankruptcy of AstroPower. The General Electric Corporation purchased the AstroPower assets in early 2004.

3.2.4 RWE/Schott (Formerly ASE Americas):

RWE Schott (formerly ASE GmbH), purchased the assets and technology of Mobil Solar in 1993 and established ASE Americas. The edge-defined film growth (EFG) process was refined and new pullers were installed. RWE purchases poly-crystal silicon that is melted. Sheet silicon is pulled from the melt in the form of an octagon. The octagon sides are cut into 15-cm x 15-cm slices. Cells and modules are produced in a semi-automated plant. The crystal-silicon modules use a glass/proprietary dielectric/cells/dielectric/glass configuration. RWE/Schott sell slices, cells and modules. Large 200- to 300-W modules are standard sizes. 25-year warrantees are offered. In 1998-1999, ASE Americas completed a major expansion of its plant in Billerica, MA. In 2003, RWE Schott produced and shipped 8 MW of cells and 4 MW of modules. RWE Schott also produced 16 MW of slices, which were shipped to RWE Schott GmbH for its cell manufacturing facilities in Germany.

3.2.5 Solec International:

Solec International terminated its cell and module production in 2000 in order to produce nearly 5 million n-type slices for its owner Sanyo. The slices are used to produce Sanyo's new HIT, amorphous silicon on crystal silicon heterojunction cell. (Note Sumitomo and Sony are joint owners of Solec). Sanyo has obtained large area (>100 square centimeter) efficiencies of 21%, with production efficiencies reaching 17.5 % with the amorphous silicon deposited on single-crystal silicon heterojunction cell.

3.2.6 United Solar Systems Corporation (USSC):

United Solar Systems Corporation (USSC) started production in its 5-MW, triple-junction amorphous-silicon plant in Troy, Michigan in 1997. Over 4.0 MW of modules were shipped in 2002. In addition to its marine modules, and framed power modules, USSC manufactured two unique products. They include a photovoltaic roof shingle that can be used with normal shingle roofing materials and a standing seam metal roofing material that can be used with metal roofing. The new building-integrated products are listed by Underwriters Laboratories (UL) and have been certified by the Arizona State University Photovoltaic Testing Laboratory. In 2000, Energy Conversion Devices, USSC's owner, signed an $84 M joint venture agreement with Bekaert (Belgium). Bekaert is a 50% owner of Bekaert/USSC and they funded construction of a 25-MW amorphous production line in Michigan. Production from the new plant commenced in late 2002. In 2003 Bekaert discontinued their interest in the United Solar plant and sold their ownership to United Solar parent Energy Conversion Devices. This 25-30 MW plant is the world's largest thin-film plant. United Solar shipped 7 MW from the new plant in 2003. An important product is their "Peel and Strip" roofing material that glues directly on a standing seam roof.

3.2.7 Evergreen Solar:

Evergreen took the string-ribbon process into production. Pilot production started late in 1997. The modules have been certified by the Arizona PV Testing laboratory and are UL listed. About

400 kW of string-ribbon modules were shipped in 2001. In 2000 Evergreen made a successful initial public offering on the United States stock market. The proceeds were used to build a 10-MW string-ribbon plant in Massachusetts. Pilot production on the new plant was achieved in the 2nd half of 2002. The new plant was dedicated ahead of schedule in June 2002. Evergreen produced 2.6 MW of ribbon modules in 2003.

3.2.8 Ebara Solar:

Ebara has taken the Westinghouse dendritic web process into pilot production. Initial production was started in 2001. In 2002, Ebara lost support of its Japanese benefactor. It is not clear what the future holds for Ebara Solar. In 2003 Ebara was purchased and renamed Solar Power Industry Corp. No products were shipped in 2003.

3.2.9 First Solar (formerly Solar Cells Inc):

First Solar continues pilot production of cadmium-telluride modules using a continuous closed-space sublimation process to deposit the CdTe on glass coated with a transparent conducting oxide. Modules measuring 61 cm by 122 cm have been produced with efficiencies of over 8%. In late 1998, Solar Cells Inc. formed a joint venture called First Solar, LLC. First Solar is in the final stages of completing its 100-MW CdTe coating line and a 25-MW cell and module production line. The coating line and the first stage of the cell and module line (about 10 MW) were to be completed in late 2000. After over a year of "fine tuning", production from the new plant was delayed until 2003. First Solar produced nearly 3 MW of cadmium-telluride modules in 2003. 2004 production is expected to be 6 MW.

3.2.10 Energy Photovoltaics (EPV):

Energy Photovoltaics (EPV) produces amorphous-silicon modules and has developed pilot production of copper-indium-diselenide cells. EPV installed an amorphous-silicon production facility at DUNASolar in Hungary and also installed an amorphous silicon line in Sacramento CA (CalSolar). DUNASolar provided nearly 2 MW of modules for the SMUD Pioneer II program. In 2001/2002 EPV announced new plant orders in China and Egypt, with a potential factory in Thailand. In 2003 the DunaSolar plant was moved to Thailand and is now called Thai Solar.

3.2.11 Amonix:

Amonix has advanced the "point contact" cell into a production-model, 24%-efficient, concentrator cell at 250 to 350X concentration. During 2002, Amonix produced about 500 kW of its 20-kW system using its design for all components. The systems operated with installed efficiency over 18%, which was a record for photovoltaics. Amonix increased production capacity to 1 MW/year in the last half of 2002 and shipped 700 kilowatts in 2003.

3.2.12 Entech:

Entech has shipped a cumulated total of nearly 500 kW of line-focus, low-concentration (18-22 X) systems. Entech has worked in the field for nearly 20 years and has continuously improved the performance and reduced the cost of its concentrator modules. Entech purchases cells from

the cell manufacturers. No shipments were reported in 2003. Entech was awarded a contract from the Department of Energy to develop a concentrator for the very high efficiency, III-V technology, 33% efficient cells for its space cell applications.

3.2.13 SunPower:

SunPower is producing arrays of very high efficiency, single-crystal silicon cells using processes developed by its president, Dr. Richard Swanson. Although SunPower can make excellent concentrator cells, they have not sold or installed concentrators using its cells. In 1997, Honda Motors made an equity investment in SunPower. This investment could lead to the production of concentrators based on Dr. Swanson's "point contact" cell. In 2003, SunPower shipped a few hundred kW of very high efficiency (about 20%) cells. Cyprus Semiconductor purchased a major equity in SunPower and funded the construction of a 5 MW plant in the Philippines. Production is expected in late 2004.

Table 8 below shows typical factory module prices for large customers in the United States. Included are modules imported mostly from Japan. Module prices to end-users are much higher, depending on the position in the distribution chain. A $3.00 factory price to a large distributor can be as high as $5.00 per Watt to a retail customer of a small dealer.

Table 8: Typical Single and Multi-crystal Silicon Module Prices $ US

YEAR	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
PRICE*	4.25	4.25	4.00	3.75	4.00	4.15	4.00	3.50	3.75	3.50	3.25	3.00

*Estimated by PV Energy Systems

3.3 Manufacturers and suppliers of other components-- Balance-of-Systems:

Typically, the balance-of-systems components for a photovoltaic system cost as much, if not more than the retail price of the photovoltaic module. About one-half of the installed photovoltaic systems involve stand-alone systems that have storage (usually deep cycle lead-acid batteries) and charge controllers that control the charging of the battery to extend the service life by optimum charging and preventing the load from exceeding the design discharge levels. Most stand-alone systems have dc loads and use 12- and 24-volt battery banks. When ac loads are used, the stand-alone system will have an inverter. Some stand-alone systems are designed as hybrids with diesel or gasoline generators as an integral part of the system.

The United States installed about 37 MW of grid-connected systems in 2003. The systems use all types of photovoltaic modules and are usually connected to an inverter that permits the photovoltaic system to first serve the building's load and then to send excess power to the utility grid. When the grid power is not available, the inverter may be designed to switch to "standby" and power the local load from energy stored in a battery bank.

3.3.1 Inverter Manufacturers

There are several inverter manufacturers serving the United States market. They all have markets for inverters other than photovoltaics, and some export a large percentage of its product. In 2000, much of the United States photovoltaic inverter industry was consolidated under Xantrex

in Canada. Xantrex acquired Trace Engineering, Heart Interface, and StatPower. Trace was the largest manufacturer of inverters for photovoltaics with over 30,000 inverters (mostly off-grid) shipped in 2002. Other producers included Advanced Energy Systems Inc., Heliotrope General, and Vanner Weldon. In 2000 SMA (Germany) opened a sales office in the United States to sell its UL-listed grid-connected residential inverters. In 2001, SMA claimed to have sold 30% of the grid-interactive inverters in the United States market. The SMA market share for 2003 was reported to be greater than 75% for numbers of residential grid-interactive inverters. The dramatic increase in the market for grid-connected residential photovoltaic systems in 2002-2003 greatly increased the sales of small inverters. Sharp, which installed over 60,000 inverters in Japan, entered the US market in 2003. At least six companies have inverters listed by Underwriter Laboratories for the US grid-connected market.

The lowest prices are the inverters supplied to Sacramento Municipal Utility District under its long-term contract with Trace (now Xantrex). Prices have not decreased much in the past few years.

Battery charge controllers

Battery charge controllers are an essential component for the PV systems that store the energy in batteries. The charge controller regulates charges going to the battery and controls the discharge of the battery to the load. The charge controller is designed to optimize the charge and discharge of the battery so as to obtain maximum battery life and provide the highest charge and discharge efficiency. The United States has several producers of charge controllers. Based on a phone survey of most suppliers the number-one US producer was Morningstar Corporation with production of over 75,000 charge controllers. Other producers in the 10,000 units per year range included, Xantrex, Specialty Concepts, Sun Selector, and RV Power Products. Several producers including ETA Engineering, Orion, PICO, ICP Global Tech, and DYNAGE POWER were not contacted for this survey. Total production is estimated at 130,000-150,000 units per year. Most of the US product over 60% is exported.

3.2.3 Systems Designers and Installers

There are about 30 companies in the United States primarily dedicated to the design, sale and installation of PV systems. When the market was primarily off-grid stand-alone systems (prior to 1996), large distributors (ten) had a systems designer-installer who served most of the larger commercial systems (telecommunications, water pumping, remote military, etc.). These include Atlantic Solar, Home Depot, Hutton Communications and SunWize. When the state tax credits for grid-connected systems (residential and commercial) were established, several of the distributors became full service systems installers. Many new or expanded companies were formed to deal exclusively with grid-connected systems. The most notable of these companies is PowerLight, which installs over 20% of the US grid-connected systems. PowerLight combines PV with foam insulation to form building-integrated flat roofs. Several 2003 PowerLight systems installed in 2003 were larger than 1W.

Table 10. Turnkey Prices of Typical Applications

CATEGORY/SIZE	Typical Applications Brief Details	Price per DC Watt ($)*
Off-grid (UP to 1 kW_p)	Stand-alone dc with 4-10 days storage.	$12-$25
Off-grid (> 1 kW_p)	Stand-alone dc or ac with 4-10 days storage.	$12-$20
On-grid (Up to 10 kW_p)	Roof-mounted/inverter/No storage.	$7-$10
On-grid (> 10 kW_p)	Roof or ground-mounted/inverter/no storage.	$6.50-$9.00

3.4 System Prices

The increased volume for grid-connected PV systems has caused intense competition, more effective use of installation labor, packaged systems and purchasing power. These changes have led to a reduction in installed system prices.

Table11: National Trends in System Prices for Grid-connected Residential Systems.

YEAR	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
PRICE $/W	12	12	12	11-12	10-12	10-12	10-11	9-11	8-10	7-9	6.50-9	6.50-8.00

*Prices do not reflect add-on costs for warrantees, service contracts and training. Additional energy storage for uninterruptible power will also increase costs.

3.5 Labor Places

The labor analysis uses the model developed in 2002. A working chart is shown below.
The TOTAL labor places in the US PV industry are about 1950 persons.

Table 12. Summary of Labor Places in the US

Category	(MW)	Total Value	Labor$ /W	$ For Labor	Labor $/Person	Number of Laborers
Cell/Module Production	102	$306M	1.25	127.50M	35,000	364 Factory
Factory Marketing	102	$306 M	0.60	61.00 M	100,000	61 Marketing
Management	102	$306 M	0.30	30.6 M	150,000	20 Management
Research/Eng Industry	102	$306 M	60.00	61.2 M	130,000	47 Research
University/Lab Research/Eng.				40.0 M	130,000	31 Research
BOS Production	66	$200 M	0.50	33 M	40,000	83 Factory
Module Sales/Distribution	40	$200 M	1.00	40 M	40,000	1000 at Dealers and Distributors
BOS Marketing	66	$200 M	0.25	16.5	60,000	28 Marketing
BOS Management	66	$200 M	0.25	16.5	80,000	21 Management
Installation Labor	60	$200 M	1.00	60 M	30,000	200 Installers
Install/Manage	60	$480 M	0.50	30 M	60,000	50 Managers.
Total LABOR						**1904 TOTAL**

a) Research and development (not including companies**); 50 PROFESSIONALS**
b) Manufacturing of PV system components, including company R&D**; 500**
c) All other, including within electricity companies, installation companies etc. **1400**

TOTAL = 1950

The US PV production is decreased in 2003 compared to 2002 owing to two major factors.

1. The production of BP SOLAR (US) is decreased because the cast ingot poly plant (Solarex) produced only enough cells and modules to service the North American Sales. Slices were shipped to BP Solar plants in Europe, India, and Australia, where cells and modules were produced. BP Solar US experienced a significant reduction in force.
2. The AstroPower financial situation resulted in over a 10 MW decrease in Production. Nearly 100 employee positions were terminated.

3.6 Business value

The value of the photovoltaic product and services in the United States can be estimated by adding the total value of the product installed, the product exported and the R&D costs in the in government labs and universities. The following lists the key elements of this analysis.

32 MW of grid-connected PV Systems at an average price of $8.00/WAC	$ 256 M
9 MW of off grid consumer product at an average price of $10/watt	$ 90 M
16 MW of off grid Industrial/Commercial at $15.00 per watt	$ 240 M
5 MW of utility-owned large systems at $10.00 per watt (AC)	$ 50 M
1 MW of government projects at $12 per watt	$ 12 M
54 MW of cell/module exports at $ 3 per watt	$ 162 M
Federal, University, private R&D (not expensed in product)	$ 60 M

TOTAL = $ 870 MILLION

4 Framework For Deployment (Non-Technical Factors)

The United States photovoltaic industry continues to address the grid-connected power market through programs such as the Sacramento Utility PV Pioneer Program moving into customer purchase of photovoltaic home systems, the California subsidy for photovoltaic systems, the Los Angeles Department of Water and Power PV subsidy program, several new State subsidy programs and other market-centered programs. All are combining in forming the base for the expanding United States grid-connected photovoltaic market.

4.1 New Initiatives in Photovoltaic Power Systems

There were no new initiatives started in 2003 in the United States. Initiatives that were in effect and continuing from previous years included:

The SMUD Solar Pioneer Program, Phase II

The Sacramento Municipal Utility District (SMUD) completed the PV Pioneer I (PVP I) program where over 400 homes were equipped with SMUD-owned and maintained photovoltaic systems. The PV Pioneer II (PVP II) program offers the sale of subsidized grid-connected photovoltaic systems to customers. Over 6 MW of systems were installed in the last five years. About 400 kW were installed in 2003. A total of 11.4 MW of grid-connected PV systems have been installed by SMUD in the past eleven years. Nearly 400 kW were installed in 2003. Under SMUD's Solar Advantage Homes program, production homebuilders offer commercially built homes with photovoltaic systems as an offered feature. The systems are now available in 15 Sacramento new home communities.

The California Photovoltaic Subsidy Program

The State of California started several programs to stimulate the purchase of PV systems. The largest is a cash subsidy for the purchase of residential and commercial PV systems- the California Emerging Renewable Energy Buy-down program- administered by the California Energy Commission. The subsidies (50% of installed cost) started at $4.50 per peak AC watt in 1999 and decreased to $3.80 per watt in 2003. Nearly 30 MW of PV systems have been installed as a result of this program. Over 12 MW were installed in 2003 under this program. The California Public Utilities Commission, Under a Renewal Portfolio Standard (RPS) led four major utilities (Pacific Gas & Electric, Southern California Edison, San Diego Gas & Electric, and Southern California Gas Company) to install 11.4 MW of PV (9.9 MW in 2003). Thirteen Municipal Owned Utilities also installed over 1.2 MW of PV. In addition the Los Angeles

Department of Water and Power (the largest municipal utility in California) installed over 3.8 MW in 2003 and 7.5 MW cumulative. Since its inception, the California initiative has installed nearly 60 MW of grid-connected PV.

Other State Initiatives

Illinois: Led by the strong "Brightfields" program in Chicago (where abandoned factories (Brownfields) are converted to photovoltaic manufacturing plants (owned and operated by Spire Corporation) or installed photovoltaic systems. The state of Illinois passed the largest subsidy in the United States for photovoltaic systems, $\$6.00/W_p$. Over 1 MW of photovoltaic was installed in Illinois in 2003.

Ohio: A primary objective in Ohio is support for 50 schools to have photovoltaic systems/training modules installed on public schools.

New Jersey: New Jersey has the second most aggressive state support in the United States with $5.00/W cash payments, Set asides for PV and strong support for city support of PV with stable multi-year budgets could prove a volume market for PV commercial and residential systems.

New York: New York has legislated over $150 M to support new industry, new installations, and studies to accelerate commercialization of photovoltaic systems. New York increased the photovoltaic subsidy to $5.00/W in May 2002 for grid-connected systems.

Virginia: Virginia offers a $0.75/W cash rebate for installed photovoltaic modules produced in the state. This program is capped at $6 M per year.

North Carolina: North Carolina offers a 35% tax credit for photovoltaic system installations.

4.2 Indirect Policy Issues

The United States has completed virtually no indirect policy initiatives that affect the deployment of photovoltaics. The international policies that affect the use of photovoltaic power systems are few. In the general aegis of "free trade", the NAFTA (North America Free Trade Agreement) with Mexico and Canada permit the sale of photovoltaic systems to these markets without duty or trade restrictions, while there are duties for modules imported into Mexico from other countries. The United State's trade with all of the Americas leads to more open markets for United State's photovoltaics.

The United States has not introduced environmental regulations that have affected the deployment of photovoltaics. Neither the global warming treaty (Kyoto Accord) nor any part of the treaty has been approved by the United States Congress. Some analysts have reported that photovoltaic credits would be less than one cent per kilowatt-hour if there were serious efforts to credit photovoltaics for mitigation of CO_2 (the carbon tax). Although there was some analysis of the externalities and hidden costs of conventional energy generation compared to renewable energy in the 1990-1995 time frame, most of these studies have been stored in files and no policy action has resulted.

Deregulation of the Electric Utility Industry

The United States photovoltaic industry is benefiting from the federal government's deregulation of the electric utility industry. Utilities have been regulated monopolies in each of the 50 states, but the federal government has now required the states to deregulate utilities and permit the free trade of electricity generation, distribution and service across the country.

The deregulation process has resulted in several programs being proposed and legislated that affect photovoltaics. These include "Green pricing", set-asides for photovoltaics, net metering, interconnection requirements, etc. Owing to the fact that the regulation of the production and distribution of electricity has been relegated to the states, the initiatives related to promotion of photovoltaics are individually created and adopted by each of the 50 states. The state programs are so diverse that it is virtually impossible to provide a summary.

In order to provide a detailed overview, the United States DOE has funded project DSIRE (Database of State Renewable Energy) at the North Carolina Solar Energy Center. The Interstate Renewable Energy Council manages the DSIRE project. The DSIRE project has issued a report "National Summary Report on State Programs & Regulatory Policies for Renewable Energy" that summarizes over 120 regulatory incentives in 45 states. The report and the latest updates can be found at the web site, DSIRE on line at http:/www.ncsu.edu/dsire.htm. Owing to the fact that the 50 states are responsible for implementing the federal utility restructuring mandate, this report has been invaluable for state advocacy groups and energy planners and regulators.

Because there are over 3000 private and public electrical utilities in the United States, and all are regulated in detail by the 50 states in which they reside under a federal policy umbrella, a coherent picture is difficult to construct. The two main federal rules affecting photovoltaics are the Public Utilities Regulatory Policy Act (1978) (PURPA) and the Utility Restructuring Law (1996). The UPVG program was (now complete) also an important development process for the utilities to identify and gain experience with early applications for photovoltaics.

PURPA established the independent power industry in the United States by requiring that the utilities permit on-line third party generation of electricity and that the utility allows on-line interface with grid back up of the system. Not only was the utility required to permit interconnection, it must pay for excess electricity at "avoided cost". This law, approved by the United States Supreme Court established a large and growing independent power industry.

All generation options were allowed. Wind energy and photovoltaics benefited some from the law. However photovoltaics, with its high installed costs, despite a 10% investment tax credit, and some state tax-credits, was too expensive to compete with natural gas powered turbines. With the Million Solar Roofs Initiative, State and Federal tax credits, utility leadership, and reduced prices, coupled with restructuring initiatives, the PURPA regulations are vital to deployment of photovoltaics and other renewable energy sources.

Restructuring

Since the federal government passed a law designed to deregulate the utility industry, some of the state monopolies have been replaced with competition and the market is being broken up into generation, transmission and distribution, power sales, and service. This means that new companies offering lower rates, improved quality and better service may directly contact the customer. This has opened the door for the sale of "green energy", on-site energy generation and other services that favor the intrinsically distributable photovoltaic option. The renewable energy industry has worked with the states that are leading the deregulation process to be sure that such options as net metering, green pricing, and set-asides for environmentally benign renewables are included in the restructuring regulations. At the end on 2003, twelve states had enacted restructuring legislation. Seven of the states have provisions for renewables through the legislation of systems-benefits charges and/or renewable portfolio standards. There is more emphasis on drilling for oil, so-called "clean coal", and "safe nuclear" and decreased emphasis on renewable energy developments under the current US Government administration.

The electricity supply and price problems in California did not add momentum to the deregulation progress. The California experience has caused delays in other state deregulation processes but will undoubtedly provide insight for other states as they address deregulation.

4.3 Standards and Codes

The electrical and personnel safety codes and standards have undergone continuous updates and thorough examinations by designers, installers, inspectors and users in the United States over the years. The vital safety and interconnect issues associated with codes and standards are important activities among the photovoltaic industry. The U.S. DOE National Photovoltaic program funds and supports a large portion of this work. The work has provided a consensus of utility- and industry-input into the National Electrical Code® (NEC®), new and revised listing and certification standards, interconnect standards, and standards activities in the international arena.

An industry forum recently submitted 23 proposed changes in Article 690 – Solar Photovoltaic Systems, for the 2005 edition of the NEC. Additional proposals came from other sources through a public input process. For details on the proposed changes contact Ward Bower at Sandia National Laboratories. (E-mail wibower@sandia.gov.)

The Institute of Electrical and Electronic Engineers (IEEE Std.1374) "Guide for Terrestrial Photovoltaic Power System Safety" was completed and published in 1998 and is being updated. The updates are to make this standard conform to the 2002 NEC. The IEEE Standards Coordinating Committee (SCC21) obtained that was responsible for the IEEE Std 929-2000 utility interconnect guideline for photovoltaic systems is continuing progress on a new interconnect standard, labeled and approved as IEEE Std 1747, to address interconnection of all distributed generation. This activity has a tremendous representation by the utilities and is supported by the national laboratories. Personnel from Sandia National Laboratories and NREL headed up other IEEE standards and other certification activities. The United States actively participated in the International Electrotechnical Commission activities for photovoltaic-related standards. Underwriters Laboratories finalized the UL1741 "Standard for Static Inverters and Charge Controllers for Use In Photovoltaic Power Systems", but is now revising to include

inverters and charge controllers for all distributed generation to match the requirements of the IEEE 1747 standard. The first UL1741 was published in May 1999 and was last amended in 2001. Coordination with both the NEC and the IEEE interconnect guidelines will remain a valuable activity for finalizing the new UL1741 standard.

PowerMark Corporation continued as a non-profit certification body for the U.S. photovoltaic industry. PowerMark recognized the Arizona State University PV Testing Laboratory (PTL) and approved it for performing module certification tests based on the accreditation certificate they received from the American Association of Laboratory Accreditation. The PTL regularly performs tests on all types of photovoltaic modules according to IEEE 1262, IEC 1215, and PV-3 for crystalline silicon and IEEE 1262, IEC 1646, and PV-3) for amorphous silicon. Some testing also includes UL 1703 requirements. Most of the modules qualified meet reciprocity requirements with European standards. The Arizona PTL tests are accepted throughout the world for international purchases.

4.4 Certification of Installers and Hardware

Both hardware and practitioner certification programs are being developed in the United States. A certification program for photovoltaic inverters was initiated by Sandia National Laboratories to better characterize the operation of inverters and to certify the performance relative to power throughput. The national voluntary certification program for photovoltaic installers was launched in 2003 with nearly 100 applicants for the first round of testing. In addition, several states have or are planning to develop state-level mandatory licensure for solar installers.

The national voluntary practitioner certification program is being spear headed by the North American Board of Certified Energy Practitioners (NABCEP). NABCEP board members are volunteers representing photovoltaic and solar thermal manufacturers and installers, federal, state and local government, policymakers, labor, contractors, and training organizations. Much of the technical input to develop the task analysis, applicant study guide, tests, and general requirements evolved from component and system monitoring and evaluation tasks within the United States DOE National Solar Program. Sandia National Laboratories, along with its strategic team members and partners that include the National Renewable Energy Laboratory, the Solar Energy Industries Association (SEIA), the Florida Solar Energy Center (FSEC), the Southwest Technology Development Institute (SWTDI), the Institute for Sustainable Power (ISP), and the Interstate Renewable Energy Council (IREC) spurred practitioner certification efforts by focusing on the initial goal of establishing a voluntary practitioner certification program that could be adopted by all states for installers of photovoltaic systems.

5 Future Trends, Highlights and Prospects

It is anticipated that the United States photovoltaic production will resume expanding at least 20 percent per year, both in applications and total production.

Plant Expansion: Most plant expansion will be dedicated to; 1) production at the ECD- United Solar 30-MW amorphous silicon plant (2003/2004); 2) full operation of the Shell Solar CIS plant 3) operation of the First Solar 20-MW cadmium-telluride plant; and 4) completion of the

Evergreen 10-MW string-ribbon plant. No new PV-cell or module manufacturing plants were announced in 2003 in the United States.

The Market: The United States photovoltaic market will experience major sales increases primarily due to the State subsidies, especially California, New Jersey, Illinois, Arizona, and New York. Major changes in the United States market (growth greater than 30% per year) are expected once profitable factory prices of $2.00/W or less for photovoltaic modules and installed costs of $4.00/ W(AC) are offered.

Technology: The production of thin films (copper-indium-diselenide, and cadmium telluride) from new facilities in the United States will provide a market test for new, lower manufacturing cost, module options. Experience with thin-film performance, stability and reduced costs is expected to compete with the dominant sliced single- and poly-crystalline silicon product, and the creation of new markets for flexible light-weight, thin-film products will assure further market growth and penetration.

Continued progress in the cast-ingot polysilicon technology with increased cell efficiency (in production), volume production (with its reduced material costs), and automation (with its reduced labor costs) will maintain a robust market for the workhorse of the market and build a base for even future expansion.

6 Acknowledgements

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Annex A Method and Accuracy of Data

The data in this report are primarily the result of the annual survey of photovoltaic industry shipments performed by PV Energy Systems, Inc., and published in *PV NEWS.* All United States photovoltaic manufacturers formally responded to the survey. The United States results are crosschecked with the United States DOE Energy Information Reports. The 2003 data could not be crosschecked because the EIA report has not yet been issued. There is some uncertainty in the base data in that details on inventories are not tracked. These data are believed to be accurate to ±10%. The installation data for the United States is a result of an extensive phone survey by the author with key manufacturers, distributors, and systems integrators. The accuracy of the United States installation data is estimated to be in the ±10 % range. The currency used in this report is United States Dollars ($).