

PV REVIEW

World Solar PV Market Continues Explosive Growth

Lead by subsidized grid-connected photovoltaic markets in Japan, Germany and California, USA world photovoltaic production and market growth continued apace in 2004. Paul D. Maycock, PV Energy Systems, Inc., provides an update on the current world PV market situation.

World photovoltaic cell and module production increased in 2004 to 1195 MW representing a massive 57% increase on 2003 (716MW). Japan lead the way again with Japanese PV cell and module production increasing by 65% to 602 MW in 2004. European production increased by 49% to 314 MW whilst in the United States production increased 35% to 139 MW. Elsewhere the balance of world production increased 67% to 140 MW (Table 1).

In 2004 the top 14 producers of PV cells and modules produced 87% (1055 MW) of the world production (Table 2). Putting this into context, it is interesting to note that 500MW of PV is about equivalent to one 500 MW gas turbine used for peaking power (at 20 % capacity factor) making world PV production in 2004 equivalent to two large utility scale gas turbines. Japanese companies maintained first and second positions with Sharp at 324 MW and Kyocera at 105 MW. BP Solar (85 MW) claimed third position with Mitsubishi and Q.Cells tying for 4th and 5th position with 75 MW. Following the lead pack came Shell Solar (Siemens Solar) 72 MW at 6th and Sanyo (with production of its high efficiency amorphous silicon/crystal silicon heterojunction product, HIT) in 7th place.

Grid-connected PV

Based on an extensive phone survey, it was estimated that the grid connected residential/ commercial sector grew from 360 MW(AC) in 2003 to over 610 MW in 2004. Japanese installations in calendar 2004 increased to 240 MW and German installations were about 250 MW. Other growth was in the United States at 58 MW

and Europe about at 40MW. Table 3 summarizes the data from 1993 to 2004 by principal market sector. Owing to the dramatic increase in the cost of silicon feedstock and a shortage of modules the price of single crystal and polycrystalline silicon modules increased to the \$2.90-\$3.50 per Watt installed range.

Crystalline silicon

Nearly 85% of world PV cell and module production was based on sliced single crystal and polycrystalline silicon cells (1011MW). Despite new plants announced in the thin film area, only 47MW of amorphous silicon (3.9%) was produced. In 2004, 3 MW of copper-indium-diselenide (CIS), and 13 MW of cadmium telluride (CdTe) was produced. Over 60 MW of Sanyo's amorphous silicon on crystal silicon slice (HIT) was produced. Despite several thin film plants being ready for production expansion, single crystal and polycrystalline silicon production should continue to dominate the PV product for several more years. Table 4 provides a full listing of world cell production in 2004 by cell technology.

US activity

Production

United States cell/module production totalled 138.7 MW in 2004, which was a 35 % increase. The increase was driven by doubling production at United Solar, First Solar, and Evergreen. BP Solar grew slowly, despite the doubling of plant size at the Frederick, Maryland facility. General Electric restored production at AstroPower to 25 MW after acquiring the company late last year. Production by manufacturer is shown in Table 5. It should be noted that

the US corporation SunPower is not listed owing to the fact that all production is in the Philippines.

Thin-Film Commercialization

United Solar Systems Corporation's (USSC) 30-MW roll-to-roll amorphous silicon plant produced 14MW in 2004. United Solar announced plans to build another 30 MW amorphous silicon on steel plant to be operational late in 2006. Shell Solar shipped 2 MW of CIS photovoltaic modules. First Solar shipped 6 MW of CdTe modules and announced plans to produce 20MW in 2005. Global Solar produced over 1 MW of CIS on steel modules. Iowa Thin Film Technologies produced about 100 kW for specialty small power applications.

US PV Installations

Installations in the United States increased from 63 MW (not counting systems sized less than 40 watts) in 2003 to 86 MW in 2004. Most of the growth was in the grid-connected sector from 38 MW in 2003 to 62 MW in 2004. Imported modules doubled to over 40 MW. Most were from Japan (Sharp and Kyocera). In the state of California alone, installation of Photovoltaic Systems nearly doubled to 36.5 MW in 2004. The California PV program involved several key players and received unique assistance. Specific highlights were: The California photovoltaic "buy down" program resulted in installation of 19 MW of grid-connected residential and commercial grid-connected photovoltaic systems.

Further information

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Table 1: World PV production

Country	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
U.S.	34.75	38.85	51	53.7	60.8	74.97	100.32	120.6	103.02	139
Japan	16.4	21.2	35	49	80	128.6	171.22	251.07	363.91	602
Europe	20.1	18.8	30.4	33.5	40	60.66	86.38	135.05	210.35	314.4
ROW	6.35	9.75	9.4	18.7	20.5	23.42	32.62	55.05	83.8	140
Total	77.6	88.6	125.8	154.9	201.3	287.65	390.54	561.77	761.08	1195

Source: PV NEWS VOL 24 APRIL 2004

Table 2: Top PV Cell/Module producers (Production in MWp-dc). Rankings for each year in brackets.

Company	2001	2002	2003	2004
BP Solar	54.2 (2)	73.8 (2)	70.23 (4)	85 (3)
Kyocera	54 (3)	60 (3)	72 (3)	105 (2)
Sharp	75.02 (1)	123.07 (1)	198 (1)	324 (1)
Shell Solar	39 (4)	57.5 (4)	73 (2)	72 (6)
General Electric	26 (5)	29.7 (6)	17 (11)	25 (13)
Sanyo	19 (7)	35 (5)	35 (8)	65 (7)
Isofoton	18.02 (8)	27.35 (8)	35.2 (7)	53.3 (9)
Photowatt	14 (10)	17 (10)	20 (10)	22 (14)
Schott Solar	23 (6)	29.5 (7)	42 (5)	63 (8)
Mitsubishi	14 (9)	24 (9)	40 (6)	75 (4,5)
Motech				35 (10)
Suntech				28 (11, 12)
Deutsche Cell			17 (11)	28 (11, 12)
Q.Cells			28 (9)	75 (4, 5)
Total	336.24	476.92	649	1055.3
World Total	390.5	561.77	761	1195.2

Some volume systems, primarily to builders, were sold at low prices of \$6.50 per watt. These price reductions were made possible by continued low factory module prices for volume purchases and reduced labour costs owing to increased volume of installations.

Japanese activity

Despite the phase out of cash subsidies, Japan's PV production and applications continued their explosive growth in 2004 (Table 6). Sharp continued its strong growth in production to 324 MW in 2004. Kyocera came second with 105 MW of cast ingot polycrystalline silicon. Sanyo continued its expansion (65MW) with announced plans to more than double production in the next two years while Mitsubishi produced 75 MW. Sanyo nearly doubled production of its very high efficiency amorphous silicon on crystal silicon hetero-junction (the HIT™ cell). Shipments in 2004 topped 65 MW. The Japanese government's goal for PV production was to have production capacity over 500 MW with an in-country market of 250 MW per year and exports of 250 MW by 2005. Clearly, these goals were exceeded one year early. It is estimated that nearly 260 MW of grid connected PV was installed in 2004. The Japanese "70,000 Roofs" program completed its last year of subsidy. Over 25,000 applicants were approved in financial year 2001. (April 2001 to March 2002); 38,000 applicants in 2002;

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 1.1 MW of photovoltaic systems in 2004. Over 9 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 resulted in 2.0 MW of newly installed photovoltaic systems in 2004. Cumulative installations by LADWP reached 9.6 MW.

The California Public Utilities RPS

program with Pacific Gas & Electric, Southern California Edison, San Diego Gas and Electric, and Southern California Gas Co. installed 18.8 MW in 2004.

Other California Utilities and Cities installed nearly 200 kW.

US Costs and prices

The installed cost of grid connected PV systems decreased slightly as the cash subsidies, especially in California, decreased from \$4.50 per AC Watt installed to \$3.50 per watt. In this competitive environment the installed prices dropped from \$8.00-\$9.00 per peak watt (AC) to about \$7.00 per watt.

Table 3: World PV market by application area

	1993	1996	1997	1998	1999	2000	2001	2002	2003	2004
Consumer Products	18	22	26	30	35	40	45	60	65	70
U.S. Off-Grid	5	8	9	10	13	15	19	20	25	30
World Off-Grid Rural	8	15	19	24	31	38	45	60	75	80
Communications and Signal	16	23	28	31	35	40	46	60	75	80
Off grid commercial	10	12	16	20	25	30	36	45	50	65
Grid-Connected Residential/Commercial (AC)	2	7	27	36	60	120	199	270	360	610
Centralized >100KW (AC)	2	2	2	2	2	5	5	5	8	20
Total (MW/Year)	61	89	126	153	201	288	395	520	658	955

Table 4: 2004 World PV cell production by cell technology (MW)

Technology	US	JAPAN	EUROPE	ROW	TOTAL	%
Single crystal flat plat	85	111	115.8	29.6	341.4	28.6
Polycrystalline	14.2	393.5	158	103.5	669.2	56
Single & Polycrystalline TOTAL	99.2	504.5	273.8	133.1	1010.6	84.6
Amorphous silicon outside	14	10	8.6	7	39.6	
Amorphous silicon indoor use	0	7.5	0	0	7.5	
Amorphous silicon TOTAL	14	17.5	8.6	7	47.1	3.9
Crystalline silicon concentrators	0.5				0.5	0.04
Ribbon (silicon)	16	0	25	0	41	3.4
Cadmium telluride indoor	0	0	0	0	0	0
Cadmium telluride outdoor	6	0	7	0	13	1.1
Copper indium diselenide	3	0	0	0	3	0.25
Microcrystalline si /single si	0	20	0	0	20	1.7
Si on low-cost-substrate	0	0	0	0	0	0
A-Si on Cz slice (HIT)	0	60	0	0	60	5
Total	138.7	602	314.4	140.1	1195.2	100

52,863 in 2003 and nearly 70,000 in 2004. In 2003/4 the Japanese industry aggressively sought to increase its export sales with marketing organizations being set up in the US and Germany. Several government-assisted projects were initiated in the developing world.

Japanese residential PV program

The Japanese PV Systems Dissemination program, which started in 1994, has exceeded all of its goals. The "Residential PV System Monitor Program" initiated in financial year 1994 was renamed "Residential PV System Dissemination Program" in FY 1997. The subsidy program started with a 50% subsidy which was decreased to about 6% in FY 2004 (April 1st, 2004-March 31st, 2005). The subsidy was given to three categories: individuals installing PV on their house; private housing developers; and local public organizations building public housing. Over 200,000 residential systems were installed from 1994-2004 with a total capacity of over 800 MW. In addition to the "PV Field Test Programs- for

Table 5: US PV cell/module production

Company	1998	1999	2000	2001	2002	2003	2004
Shell Solar	20	22.2	28	39	46.5	52	62
BP Solar	15.9	18	20.47	25.22	31	13.42	14.2
General Electric							25
Astropower	7	12	18	26	29.7	17	SEE GE
USSC	2.2	3	3	3.8	4	7	14
RWE Schott (ASE)	4	4	4	5	5	4	10
Evergreen Solar					1.9	2.8	6
Global Solar						2	1
First Solar						3	6
OTHER*	0.6	1	1.5	1.3	2.5	1.8	0.5
Total	49.7	60.3	74.97	100.32	120.6	103.02	138.7

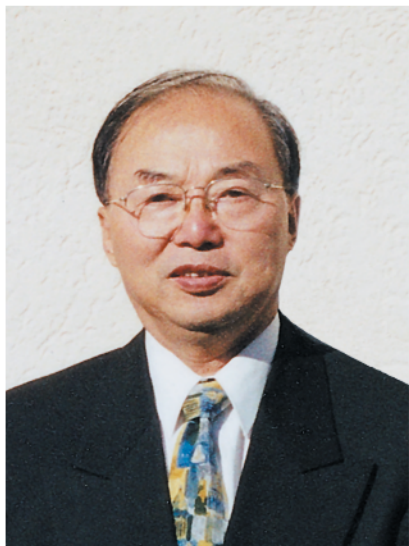
Public Facilities and for Industrial Use" (with the majority of costs borne by the government), the Public Facilities field test program, started in FY 1998 and completed in FY 2002, resulted in 740 PV systems with 18.1 MW of capacity being installed in schools, medical facilities, welfare facilities, factories, office buildings and private sector facilities. The succeeding program "Field Test for Industrial Use" had 157 projects with over 4.8 MW selected in FY 2004.

Aggressive pricing strategies are expected by Japanese companies in order to enter other growing markets. Prices have dropped in Japan for installed residential grid-connected PV systems. Prices in 1995 were nearly \$11.00 per watt and installed prices in 2004 were less than \$6.00 per watt. The next two years will be pivotal in the Japanese PV industry as the explosive growth in Japan could slow, new factories come on line, and exports are required to keep the industry moving.

Table 6: Japanese PV production

Company	1997	1998	1999	2000	2001	2002	2003	2004
Sanyo	4.7	6.3	13	17	19	35	35	65
Kaneka	-	-	3.5	5	8	7.5	13.5	20
Kyocera	15.4	24.5	30.3	42	54	60	72	105
Mitsubishi	-	-	-	12	14	24	42	75
Sharp	10.6	14	30	50.4	75.02	123.07	197.91	324
Hoxan	1	1	1	1	-	-	-	-
Canon	2.1	2	1	-	-	-	-	-
Matsushita	1.2	1.2	1.2	1.2	1.2	1.5	1.5	2.5
Mitsubishi HEL	-	-	-	-	-	-	2	10
Total	35	49	80	128.6	171.22	251.07	363.91	602

Who light chinese solar thermal market?



According to ESTIF statistics, last year around the world the total new installation has reached 17.6 Million square meters (12.3 Million Kw th), about 78% new installation in China, the new installed solar water heaters in Chinese market is more than 85% is all glass evacuated solar water heater, the total area is around 11.6 Million square meters (8.15 Million Kw th), equal to 7 times than total Europe new installation

Who light Chinese solar thermal market before 20 years?

Professor Yin Zhiqiang, study the solar selective coating before 20 years ago in Tsinghua University, he invented the special coating that named sputtering AL-N/AL solar selective coating, he and his colleagues work hard to transfer this technology from laboratory to industry, that is Tsinghua solar from, in the past years Professor Yin and his colleagues have done a good job and create many first products and ideas in the solar thermal industry.

Tsinghua solar is the first company to produce all glass evacuated solar collector tubes and systems in China, now they are still the leader on Chinese solar thermal market, Tsinghua solar has offered more than 3 million square meters in the past 20 years to the customer around the world.

Now the growth rate is still keep high in Chinese solar market, Professor Yin invented another new solar selective coating which is more stable, higher efficiency, longer span compare the original. And the new structure glass tubes will give you a definitely views, Tsinghua solar will use new solar products to boom the market in the not long future.

Why not join Tsinghua solar?

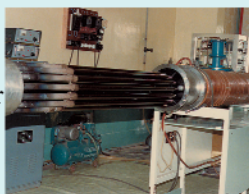
First

tube with Al-N/Al solar selective coating



First

sputtering machine for solar selective coating



First

large quantity production line for solar tubes



First

large quantity production line for solar tank



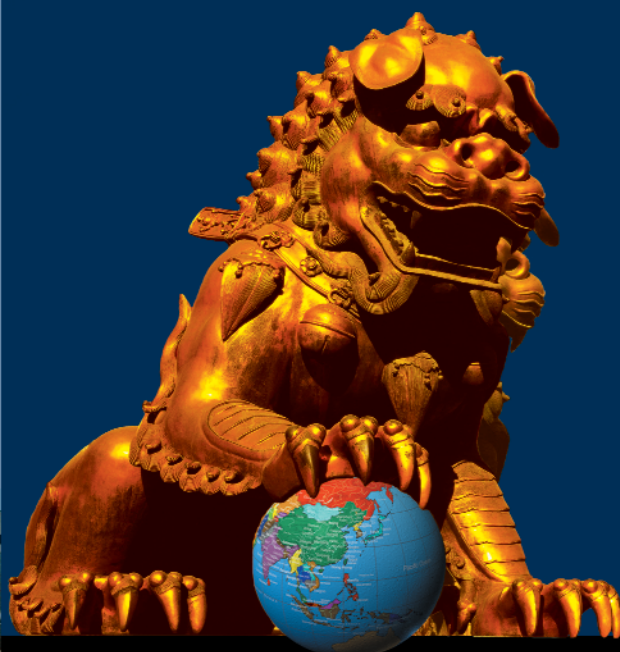
First

chinese company applying solarkey certification



First

popular type solar water heater in China



Looking for distributors around the world

Tsinghua Solar

Leader in Chinese solar market

- ★ Inventor of Al-N/Al solar selective coating.
- ★ Pioneer in all glass tubular collectors and solar water heating systems in China.
- ★ More than 20 years experience, millions of customers around the world.
- ★ Superior performance and efficiency on products and service.

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Table 7: European PV production

Company	1998	1999	2000	2001	2002	2003	2004
RWE Schott (was ASE)	3.00	7.00	10.00	16.00	24.50	38.00	53
BP Solar (Spain)	4.50	5.00	9.16	12.16	16.70	16.45	23.5
Free Energy Europe	0.60	0.60	0.60	0.60	0.60	0.60	0.5
ICP Solar(Intersolar)	1.30	2.00	2.50	3.00	2.30	2.50	2.5
Photowatt-France	12.00	10.00	14.00	14.00	17.00	20.00	22
Eurosolare (IT)	3.20	1.50	2.30	4.00	3.00	3.50	4
Helios (Italy)	1.50	1.30	1.50	2.20	3.00	3.50	4
Isofoton – Spain	4.20	6.10	9.50	18.02	27.35	35.20	53.3
Shell Germany			3.30	7.50	9.00	25.00	10
Shell Netherlands	2.00	2.00	2.20	2.80	0.00	0.00	0
RWE Phototronics	0.00	2.00	2.00	2.00	2.00	2.00	2
Konkar – Croatia	0.80	0.80	0.80	0.60	0.60	0.60	0.6
Deutsche Solar						17.00	28
Sunways					4.50	4.50	11
Q.Cells					8.00	28.00	75
Ersol					9.00	9.00	16
Antec							7
Dunasolar (Hungary)		1.20	2.20	3.00	3.00	*??	0
Other	0.40	0.50	0.60	0.50	4.50	4.50	2
Total	33.50	40.00	60.66	86.38	135.05	210.35	314.4

*Source: PVNEWS, MARCH 2005 *Dunasolar Equipment Moved to Thailand in 2003*

European activity

European PV cell and module production increased by 49% to 314.4 MW in 2004. Q.Cells jumped to 1st place with 75 MW, followed by Isofoton with 53.3 MW and Schott Solar a close third at 53 MW of production. Deutsche Solar (Solar World) produced 28 MW, while BP Solar (Spain) grew to 23.5 MW and Photowatt produced 22 MW.

The race for first place in Europe will be very exciting in the next three years. In total, European installations are estimated at 300 MW with over 260 MW in Germany, and 40 MW in the rest of Europe in 2004.

ROW

PV production around the Rest of World in 2004 increased by 67% to 140 MW (Table 8) with BP Solar producing over 48 MW of that total in Australia and India. MOTECH reported 200% growth to 28.0 MW and production in China was estimated at around 35 MW (with SUNTECH making up 28 MW of this total).

Future developments

There are exciting opportunities developing in the PV world. Despite dramatic growth in the subsidized grid connected market, excessive pressure on the module suppliers, a shortage of silicon (resulting in increased silicon costs, leading to increased module prices in 2004 and 2005); it appears that the next few years will be pivotal for the industry. Actual figures to 2004 and a forecast to the year 2010 are detailed in Table 9.

Table 8: Rest of World PV production

Company	2000	2001	2002	2003	2004
CEL (India)	1.5	1.7	1.5	2	2.5
Sinonar (Taiwan)	3	3	3	3	4
BHEL (India)	1	1.5	1.5	2	2
BEL (INDIA)			1	1	1
RES (India)	1	1	-	-	-
China (SUNTECH 28)	2.5	3	8	9	35
WEBEL (India)	1.5	1.2	3	4.5	6
UDHAYA (India)	0.5	0.5	0.95	0.95	1
BP Solar (India)	6.46	8.06	13.1	14.11	14.1
BP Solar (Australia)	5.76	6.96	8.4	26.24	34
BP Solar (Hong Kong)		1.3	3.3	0.0	0
BP Solar (Malaysia)		8.7	1.3	0.0	0
Motech		3.5	8	17	35
Maharishi				0.5	4.5
Other	0.2	0.2	0.2	1	1
Total	23.42	40.62	53.25	83.8	140.1

Table 9: Forecast of World PV market

Market Sector	1996	1998	2000	2002	2003	2004	2005	2010
Consumer products	22	30	40	60	70	75	80	160
U.S. off-grid residential	8	10	15	25	30	35	40	80
World off-grid rural	15	24	38	60	75	80	90	260
Communicate/signal	23	31	40	60	75	80	90	240
PV/diesel, commercial	12	20	30	45	50	65	80	140
Grid-connected Residential/Commercial	7	35	120	270	350	600	800	3000
Centralized >100 kW	2	2	5	5	8	20	40	120
Forecast (MW/yr)	100	150	250	500	650	900	1220	4000
Actual (MW/yr)	89	152	288	525	658	955	—	—
Forecast average price (\$/W)	—	—					3.00	2.00
Forecast low price (\$/W)	—	—					2.25	1.50
Actual average price (\$/W)	4	4	3.5	3.25	3	3.25	—	—