International Energy Agency

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 Germany 2003

Prepared on behalf of BMU – German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

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by

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i Foreword

The International Energy Agency (IEA), founded in November 1974, is an autonomous body within the framework of the organisation for Economic Cooperation and Development (OECD), which carries out a comprehensive programme of energy co-operation among its 23 member countries. The European Commission also participates in the work of the Agency.

The IEA Photovoltaic Power Systems Programme (IEA-PVPS) is one of the collaborative R & D agreements established within the IEA and, since 1993, its participants have been conducting a variety of joint projects in the applications of photovoltaic conversion of solar energy into electricity.

The twenty participating countries are Australia (AUS), Austria (AUT), Canada (CAN), Denmark (DNK), Finland (FIN), France (FRA), Germany (DEU), Israel (ISR), Italy (ITA), Japan (JPN), Korea (KOR), Mexico (MEX), The Netherlands (NLD), Norway (NOR), Portugal (PRT), Spain (ESP), Sweden (SWE), Switzerland (CHE), The United Kingdom (GBR) and The United States of America (USA). The European Commission is also a member.

The overall programme is headed by an Executive Committee composed of one representative from each participating country, while the management of individual research projects (tasks) is the responsibility of Operating Agents. Nine tasks have been established, and currently six are active. Information about these tasks can be found on the public website <u>www.iea-pvps.org</u>. The new task concerning urban-scale deployment of PV systems is now underway.

The objective of Task 1 is to promote and facilitate the exchange and dissemination of information on the technical, economic, environmental and social aspects of photovoltaic power systems.

ii Introduction

An important deliverable of Task 1 is the annual International Survey Report (ISR) on PV power applications. This report gives information on trends in PV power applications in the twenty member countries and is based on the information provided in the National Survey Reports (NSR) which is produced annually by each Task 1 participant. The public IEA-PVPS website also plays an important role in disseminating information arising from the programme, including national information.

The International Survey Report (ISR) is an external publication of the IEA-PVPS Implementing Agreement so it must not contain confidential information. Similarly, the National Survey Reports are now presented on the public PVPS website. As the International Survey Report is based on National Survey Reports it is important that experts follow agreed and annually adapted guidelines when preparing their national reports.

Like in the years before the main problem for preparing the German NSR was the fact that the data required by the NSR guidelines are not available by any central institution. For the primary data collection a lot of different sources had to be evaluated.

iii Definitions, symbols and abbreviations

For the purposes of the National Survey Reports, the following definitions apply:

<u>PV power system market</u>: The market for all nationally installed (terrestrial) PV applications with a PV power capacity of 40 W or more.

<u>Installed PV power</u>: Power delivered by a PV module or a PV array under standard test conditions (STC) – irradiance of 1 000 W/m2, cell junction temperature of 25°C, AM 1,5 solar spectrum – (also see 'Peak power').

<u>Peak power:</u> Amount of power produced by a PV module or array under STC, written as W.

<u>PV system:</u> Set of interconnected elements such as PV modules, inverters that convert d.c. current of the modules into a.c. current, storage batteries and all installation and control components with a PV power capacity of 40 W or more.

<u>Off-grid domestic PV power system</u>: System installed in households and villages that are not connected to the utility grid. Usually a means to store electricity is used (most commonly lead-acid batteries). Also referred to as 'stand-alone PV power system'.

<u>Off-grid non-domestic PV power system</u>: System used for a variety of applications such as water pumping, remote communications, telecommunication relays, safety and protection devices, etc. that are not connected to the utility grid. Usually a means to store electricity is used. Also referred to as 'stand-alone PV power system'.

<u>Grid-connected distributed PV power system</u>: System installed on consumers' premises usually on the demand side of the electricity meter. This includes grid-connected domestic PV systems and other grid-connected PV systems on commercial buildings, motorway sound barriers etc. These may be used for support of the utility distribution grid.

<u>Grid-connected centralized PV power system:</u> Power production system performing the function of a centralized power station.

<u>Module manufacturer</u>: An organisation carrying out the encapsulation in the process of the production of PV modules.

Turnkey price: Price of an installed PV system excluding VAT/TVA/sales taxes, operation and maintenance costs but including installation costs. For an battery off-grid the prices associated with storage system, maintenance/replacement are excluded. If additional costs are incurred for reasons not directly related to the PV system, these should be excluded. (E.g. If extra costs are incurred fitting PV modules to a factory roof because special precautions are required to avoid disrupting production, these extra costs should not be included. Equally to the additional transport costs of installing a telecommunication systems in a remote area are excluded).

<u>Field Test Programme:</u> A programme to test the performance of PV systems/ components in real conditions.

<u>Demonstration Programme:</u> A programme to demonstrate the operation of PV systems and their application to potential users/owners.

<u>Market deployment initiative:</u> Initiatives to encourage the market deployment of PV through the use of market instruments such as green pricing, rate based incentives etc. They may be implemented by government, the financing industry, utilities etc.

NC: National Currency

<u>Final annual yield:</u> Total PV energy delivered to the load during the year per kW of power installed.

<u>Performance ratio</u>: Ratio of the final annual (monthly, daily) yield to the reference annual (monthly, daily) yield, where the reference annual (monthly, daily) yield is the theoretical annual (monthly, daily) available energy per kW of installed PV power.

BAFA: Bundesamt für Wirtschaft und Ausfuhrkontrolle, former BAW

BMBF: Federal Ministry of Education and Research

BMWA: Federal Ministry of Economics and Technology

<u>BMU:</u> Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

KfW: Kreditanstalt für Wiederaufbau (The German Development Bank)

DENA: Deutsche Energie Agentur

FVS: Forschungsverbund Sonnenenergie

REL: Renewable Energy Law (EEG: Erneuerbare Energien Gesetz)

VDEW: Verband der Elektrizitätswirtschaft (Association of German Utilities)

 $\underline{\mathsf{VDN:}}$ Verband der Netzbetreiber, association of the grid operators within the $\overline{\mathsf{VDEW}}$

<u>DBU:</u> Deutsche Bundesstiftung Umwelt (German Federal Environment Foundation)

REMI: Renewable Energy Market Initiative by IEA-PVPS

German Associations

BSi: Bundesverband Bundesverband Solarindustrie

DGS: Deutsche Gesellschaft für Sonnenenergie

DFS: Deutscher Fachverband Solarenergie

UVS: Unternehmensvereinigung Solarwirtschaft

1 Executive summary

After stagnation in 2002, the PV market in Germany grew again strongly in 2003. The additional installed PV power was about 130 MW in 2003 compared to 83 MW in 2002.

The two main market introduction initiatives,

- the 100 000 Roofs Solar Power Programme, providing low interest loans of 1,91% since 1st January 1999 and
- the Renewable Energy Law (REL), providing buy back rates of 0,457 € for every kWh, which is generated by photovoltaic power plants and fed into the grid (in 2002: 0,481 €/kWh)

remained almost the same as in 2002.

After the elections in September 2002, the new government assured that support of PV will continue. But as the 100 000 roofs programme ended at the end of the year and a new programme was not announced, there was a final "run" on the programme. These circumstances may have at least partly stimulated the strong growth in 2003.

In 2003 the Kreditanstalt für Wiederaufbau (KfW), the responsible governmental authority for granting PV system proposals within the 100 000 Roofs Solar Power Programme, accepted 19 882 applications for PV-systems with a total capacity of 146 073 kWp. Not all of the accepted PV plants could be realized in 2003. The average size of the PV plants again increased from 5,14 kW in 2002 to 7,35 kW in 2003.

The result of the evaluation of the installed PV capacity data over the last years is shown in Figure1:

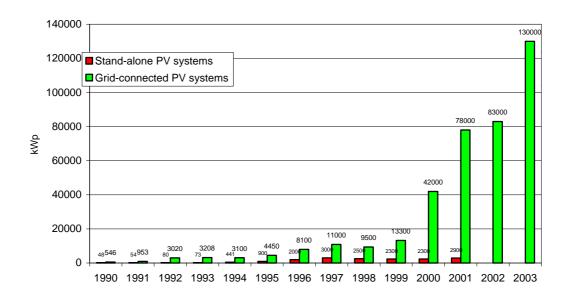


Figure 1: Installed PV Module Power for grid-connected and off-grid PV Applications per year from 1990 to 2003.

The actual installed power for 2003 was estimated for grid-connected applications at 130 MW.

Figure I shows that the off-grid PV applications are of less importance, whereas the number of grid-connected PV systems was increasing rapidly. The reason is that the market introduction programmes favour only on-grid applications with the result that the majority of system companies focus on grid-connected and sell less off-grid PV systems. For 2003 a power capacity of 3 MW off-grid applications is estimated.

The main problem of the assessment of the most important key number, the installed power per year, is the lack of accurate statistics about the actual date of the start of plant operation (assignment to the relevant year).

By the end of 2003, the production of solar cells applying all different technologies amounted to 110 MW, increasing from 57 MW in 2002. The production capacity reached 135 MW (94 MW in 2002). The German PV module production including thin film and special PV modules (flexible for car roofs and boats) amounted to 82,5 MW. This was the result of the installation of new and the extension of existing production lines. Additional solar cell and PV module production lines are in the planning or under construction.

Table 1: Total German Production and Capacity Data of PV Modules

	1996	1998	1999	2000	2001	2002	2003
Total Production	3,0	6,4	8,8	16,1	29,0	41	82,5

The German PV cell and module production increased strongly from 2002 to 2003, but due to the strong market growth still a large percentage of the modules are imported.

The growing importance of the PV market in Germany was also reflected in the number of labour places connected with PV. It is estimated that about 10 000 - 12 000 full time labour places existed in the PV industry at the end of the year 2003.

The **system prices** dropped about 10% in 2003. The average system price for the key system of a roof mounted PV systems in the power range of 2-3 kW was about 5 080 €/ kW without VAT.

The main characteristics of the *German PV market*, which led to the tremendously extending market volume and made Germany worldwide No.2 in PV installations, are as follows:

- the positive public opinion of German citizens concerning renewable energies resulting in a high demand
- the high grants on the governmental level and the possibility to combine these with the very attractive feed-in tariffs of the Renewable Energy Law
- the high number of market participants from manufacturers to system houses, installers and distributors

Some new trends are obvious:

- mainly the large manufacturers are on the way to fully integrated factories combining all steps of the PV modules production from feed stock material to module assembling under their house. Additionally some companies are offering project engineering and general contractor activities
- Large commercial PV systems in the MW range financed by PV fonds are of growing importance. This allows citizens without the possibility of having a system on their own roof, to invest in centralised PV systems of joint ownership.

The Renewable Energy Law (REL) from 1st April 2000 in combination with the 100 000 Roofs Solar Power Programme has supported the German PV market until the end of 2003. But even after that date the REL (with improved conditions) will provide a stable base for the long term support of photovoltaic systems.

The further growth of the PV market in Germany will be reached if large and new sections of the customers could be activated and the system prices will drop down noticeably (>5% per year). The price reduction will be realistic as the module production capacities in Germany and abroad are still growing and the import of PV modules will be intensified and finally result in lower prices.

2 The implementation of PV systems

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

2.1 Applications for photovoltaics

2.1.1 Off-grid applications

The off-grid sector includes domestic PV applications for the leisure such as electrical power for weekend houses. Non domestic applications are implemented in the 'mobile' sector, such as cars and caravans (sunroofs combined with ventilation), camping, boats, water pumping and electricity supply for many traffic applications and tool sheds, which are increasing and difficult to distinguish in the total number of PV systems installed in the off-grid sector.

Domestic off-grid PV systems are offered by specialized manufacturers, distributors and system-houses as well as by numerous Do-it-yourself and electronic-stores. In contrast to the grid-connected systems where there is a possibility to check our estimations with the measured generated electric power fed into the grid, it would be impossible to acquire the data for off grid PV with adequate accuracy. For that reason we do not give any numbers for off-grid installations in the German National Survey Report.

2.1.2 Grid-connected applications

The German national programmes still favour exclusively the installation of grid-connected PV power systems and this led to fewer installations of off-grid applications. Installation and system companies as well as the high majority of manufacturers focus on the installation of grid-connected, building integrated systems.

Within the grid-connected PV power applications the distributed systems are dominating. Those PV systems result from the introduction of the rate-based and cost-oriented incentives and general market introduction programmes with mainly private house owners as target group. Because the funding conditions of these programmes are aimed on an installed power per system up to 5 kW, these programmes contribute mainly to the distributed grid-connected applications.

The analysis of the granted (grid-connected) applications by KfW within the 100 000 Roofs Solar Power Programme reflects exactly the installations by number and by PV plant size. The following numbers of PV systems with the corresponding total power capacity have been approved:

Table 2: 100 000 roofs programme

	Number of PV systems accepted	Power capacity in kWp	Average system size kWp
1999	3 522	8 895	2,53
2000	7 819	36 608	4,68
2001	19 326	75 869	3,93
2002	15 191	78 053	5,14
2003	19 882	146 073 *	7,35
total	65 740	345 497	5,26

* Not all of the accepted PV plants could be realized in 2003. The average size of the PV plants within the 100 000 roofs programme again increased from 5,14 kW in 2002 to 7,35 kW in 2003.

The analysis of KfW also contains a detailed subdivision of the in 2003 granted PV system into plant sizes:

Plant sizes (kWp)	Number of granted plants in 2003	Granted power kW in 2003 (kWp)	Share of total granted power
< 1,5	363	393	0,3%
1,5 - 2	426	765	0,5%
2 - 2,5	1.029	2.293	1,5%
2,5 - 3	989	2.706	1,8%
3 - 4	2.094	7.105	4,7%
4 - 6	6.565	32.731	21,9%
6 - 10	4.034	30.359	20,3%
10 - 20	3.897	49.626	33,1%
20 - 50	556	15.065	10,1%
50 - 100	59	3.633	2,4%
100 - 120	12	1.246	0,8%
> 120	18	3.856	2,6%

 Table 3: Subdivision of granted applications into different plant sizes

Remark: These numbers are slightly different to the final statistics and were only used for the subdivision in different plant sizes.

In the table above the smaller grid-connected applications (<u>distributed systems</u>) are dominating the installed power. The installed power of plants within this application in the range up to 100 kW have reached a proportion of 96,6% for year 2003.

There is no adequate statistics available for the installed power of the few systems outside the 100.000 roofs programme. Often it is difficult to separate larger PV systems in 'distributed' and 'centralized' because larger systems were divided in several systems below 100 kW. Because of these uncertainties we do not separate any more in "distributed" and "centralized" systems in this report.

2.2 Total photovoltaic power installed

There are no key data available for the German PV market from any governmental (e.g. Statistisches Bundesamt) or non-governmental institution for 2003 as well as the years before. This refers especially to the yearly installed power, the most important figure to characterize the national PV market.

To get realistic data on the installed PV-power it was necessary to use various sources such as:

- the Federal Government Ministries (BMU, BMWA, BMBF) and their executing institutions (KfW etc.)
- the PV industry associations
- Data of various renewable energy magazines, e.g. "PHOTON"
- parent organisations of the utilities (VDEW and VDN)

As in 2002, in 2003 it was not possible to evaluate the actual installed PV power in this way without a lot of estimations. This as well as the inadequate statistics of the involved institutions makes it fairly impossible to assess accurate data with accuracy much below ± 10 %.

			•	•	•		•			
Sub-market/	31 Dec.	31 Dec.	31 Dec.	31 Dec.	31 Dec	31 Dec.	31 Dec.	31 Dec.	31 Dec.	31 Dec.
application	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW
off-grid domestic	373	500	1 100	2 100	2 900	3 450	4 200	6 200	-	-
off-grid non- domestic	413	1 187	2 587	4 587	6 300	8 050	9 600	10 500	-	-
grid- connected distributed	9 124	13 063	19 896	28 676	37 300	49 100	89 900	162 000	240 000	130 000
grid- connected centralized	2 530	3 040	4 307	6 527	7 400	8 900	10 100	16 000	20 600	
TOTAL	12 440	17 790	27 890	41 890	53 900	69 500	113 800	194 700	260 600 + non- grid	~ 400 000

Table 4: The cumulative installed PV power in 4 sub-markets

Note: The assessed accuracy is at ±10%

PV modules with a power of about 130 MW were installed in 2003 in Germany for all grid-connected applications.

2.3 Major projects, demonstration and field test programmes

Since the introduction of the 100 000 Roofs Solar Power Programme (01.01.1999) and the Renewable Energy Law (01.04.2000), other programmes initiated by the Federal States, several communities or utilities were either adapted to the regulations of these financing schemes or cancelled. So the number of funding programmes is rapidly decreasing.

Smaller projects with a broad demonstration effect such as the 'Sun at School' or '300 Parish for Solar Energy' were continued by governmental organisations.

Federal Government	Kind of Funding	Name of Programme
BMWA / BAFA	Subsidy: up to 3000 Euro/ installation	Sun at school,
BMU/ KfW		general programme
BMU/ KfW	Low interest loan (1,91%)	100 000 Roofs Solar Power-Programme
DBU (foundation)	Low interest loan (3,75%) Subsidy	Environmental and CO ₂ -Reduction Programme 300 Parishs for Solar Energy
Federal States	Subsidy	
	No gonoral funding	
Baden Württemberg	No general funding	
Bayern Berlin	No general funding	
Brandenburg	No general funding No general funding	
¥	No general funding	
Bremen		
Hamburg	No general funding	Level interpret les pre fair avial and a start DV avaitable
Hessen	Project support for PV plants outside KfW	Low interest loans for grid-connected PV systems
Mecklenburg-Vorp.	No general funding	
Niedersachsen	 Loans Subsidies for PV systems in some regions (Hannover) Subsidies for PV systems in agriculture 	 Loans for energetical modernization of buildings Max. 7 670 Euro per system
NRW	Subsidies for PV systems	REN Programme
RheinlPfalz	No general funding	*
Saarland	No general funding	
Sachsen	No general funding	
Sachsen-Anh.	No general funding	
Schleswig-Holstein	Further reduction of interest	
-	rates of some KfW	
	programmes	
Thüringen	Subsidies for PV-systems	

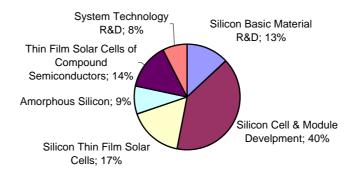
Table 5: Survey of PV funding in 2003 by governmental institutions

2.4 Highlights of R&D

Since autumn 2002 the Federal Ministry of Environment (BMU) is responsible for the renewable energies within the Federal Government. Research and Development is conducted under the 4th Programme on Energy Research and Energy Technology which aims to three main goals

- cost-reduction for solar cells and PV modules by decreasing production costs and by increasing cell and module efficiencies.
- Cost reduction, technical optimisation and removing of other obstacles preventing the use of PV in different types of buildings
- PV for decentralized, grid independent electricity supply.

Fig. 2 Funding of R&D 2003 by BMU (29, 7 Mio. EUR in total)



Crystalline silicon is still the most important material for manufacturing solar cells. Today, emphasis is placed on innovative and efficient manufacturing techniques. In 2003, some projects directly related to new production concepts of silicon wafers and cells were realised:

- NEON methods to fabricate thin multicrystalline silicon wafers which have a large area of 200 x 200 mm2,
- PLATON plasma technologies for dry surface structuring of multicrystalline solar cells,
- INKA cheap inline processes for metal contacts of high efficiency silicon solar cells.

Of growing importance is the solar grade silicon research and development: There are two main activities in this field by Wacker Chemie and a joint venture of Degussa and Deutsche Solar, a subsidy of Solar World. They are developing different processes of solar grade silicon production.

2.5 Public budgets for market stimulation, demonstration/field test programmes and R&D

In 2003 the support from the Federal Ministries (BMBF, BMWA) for R&D on PV projects amounted to about 29,7 M€ after 23,6 M€ in 2002. This amount was spent for special research projects, e.g. in the field of cell technology, or in the connection with the installation of innovative cell production lines.

Within the 100 000 Roofs Solar Power Programme, 19 882 applications for PVsystems with a total capacity of 146 073 kWp were accepted in 2003. (Not all of the accepted PV plants could be realized in 2003.)

In addition there are two small activities called "Sun at School" with a subsidy up to 3000 Euro per installation and the "300 Parishs for Solar Energy" programme.

Basic funding for the seven research institutes in the field of PV is not included in the R&D budget.

3 Industry and growth

3.1 **Production of photovoltaic cells and modules**

The German financing schemes, the 100 000 Roofs Solar Power Programme and the Renewable Energy Law (REL), are the positive background for the continuously increasing German PV market during the last years. This programme in the modified version of 1st April 2000 guarantees a maximum installed power of about 300 MW from 1999 until 2003. By the end of 2003 about 65 740 PV plants with a total power of 345 MW were granted by KfW.

In 2004 the 100.000 roofs programme will not be continued. In order to replace this market stimulating activity, the support of PV systems within the REL will be continued with improved conditions since 01.01.2004. Thus the industry has got certainty for the boundary conditions in planning their further strategy for an extended period.

During the last years, the continuously increasing power set by the programme and the high demand, generated a positive atmosphere on the German PV market led to the foundation of a lot of new companies. The installation of new production lines and production capacity extensions for wafers, solar cells and PV modules were realised. After a year of stagnation in 2002, the PV market in Germany showed a strong growth again.

The extension of the production capacity of cells and modules of most German producers in Germany was impressive: The total production of solar cells raised from 57 MW in 2002 to 110 MW in 2003.

Like in the past years, two large companies on the German PV market

- Solar World (Deutsche Solar, Deutsche Cell, SolarFactory, GPV)
- RWE Schott Solar (production USA and in Germany (Alzenau and Munich))

are following the strategy to a full integrated solar factory containing the most important steps of PV modules production in their company (all steps of added value). This guarantees more independence of the fluctuation of the PV market.

Feedstock material and Wafers

Wafers were fabricated in 2003 by three companies: the *Deutsche Solar*, former Bayer Solar, in Freiberg, *PV Crystalox Solar* in Erfurt, (a merger of PV Silicon and Crystalox of Oxfordshire, UK, in March 2001) and RWE Schott Solar in Alzenau.

In 2003, the wafer production of Deutsche Solar and RWE Schott Solar amounted to 82,5 MW . (For 2003 there are no data available for PV Crystalox. In 2002 a value of 21 MW was estimated)

Solar cells

Six companies have produced solar cells in 2003 applying different technologies such as sc-Si, mc-Si, EFG, a-Si and transparent power cells.

Ersol produced mc-Si cells in Erfurt; the production capacity in 2003 remains constant 9 MW.

Q-Cells in Thalheim produced 28 MW mc-Si solar cells in 2003.

The new cell factory of Deutsche Cell (Solarworld AG) in Freiberg/Sachsen produced 17 MW.

RWE Schott Solar, Alzenau, produced EFG and mc-Si solar cells with a capacity of 40 MW and RWE Schott Solar, PST, in Putzbrunn produces a-Si cells with a capacity of 3 MW.

Shell Solar Deutschland, has reached an output of 9 MW mc-Si cell production on their line in Gelsenkirchen in 2003.

Sunways in Konstanz, specialized on the production of semi-transparent (0-30%) so called "Power Cells", started pilot-production in June 1999 and produced standard and 'power' cells. They produced about 7 MW in 2003.

At the end of 2003, the total solar cell production amounted to 110 MW (57 MW in 2002).

It is expected that the capacity will be extended to more than 180 MW in 2004.

PV Modules

More than 400 PV module types are available on the German PV market, which are produced world-wide.

More than 20 companies are currently manufacturing PV modules for all kinds of applications in Germany.

The solar cell and PV module producers with an output in 2003 are listed in Table 4. A short information about their products and the individual activities is added.

The production of thin-film PV modules has been started by three German Manufacturers (see Table 4).

The PV module production increased from a low level of about 6,4 MW in 1998, 8,8 MW in 1999, 16,1 MW in 2000, 29,6 MW in 2001, 42 MW in 2002 to 82,4 MW in 2003.

From the 25 German PV module manufacturers, mentioned in Table 4, are

- 3 manufacturers of thin-film modules in the development or optimization phase with a total output of 7,4 MW
- 11 companies producing more than 1,0 MW per year.

In 2003, the total solar module production amounted to 82,4 MW. It is expected that the capacity will again be extended strongly in 2004.

	ell/Module anufacturer	Technology (sc-Si, mc-Si, a-Si, CdTe)	Total Proc (MW)	duction	<u>Maximum p</u> capacity (M end of the y	W at the	Additional Information
		· ·	Cell	Module		, Module	
1.	Alfasolar Vertriebsgesellschaft mbH			3 (2,5)			
2.	Deutsche Cell GmbH, Freiberg		17		30		
3.	Ersol Solar Energy GmbH Erfurt	mc-Si	9,0 (9,0)		10,0		Ersol produces solar cells with two production lines. The further extension of the production line and the start of an additional PV module production (mc-Si 160 W) is planned for 2003.
4.	Scheuten Solar Technology (former Flabeg Solar International GmbH)	sc-Si mc-Si		2,9 (2,5)	8,0		Specialized in modules (140W–230W) for integration into buildings and façades. In 2001 a new high-tech production line for standard modules with a capacity of 9,0 MW (3 shifts) was installed in Gelsenkirchen and started operation in early 2002. Recently the company became insolvent and closed the
-	GSS GmbH and IPEG GmbH, Löbichau	mc-Si		4 (2,5)			production. Manufactures mainly custom made frameless PV modules (80- 290W) for integration into buildings. Acquired in 2000 by Atlantis Energie AG. IPEG is a spin-off company of GSS.
6.	Q-Cells AG, Thalheim	mc-Si	28,2 (9,0)		24,0		A new company on the market in 2001. The cell production line has been designed for maximum performance and flexibility: to produce high performance and process both poly- and mono-crystalline materials and to handle formats of 100, 125 or 150 mm cells Start of production in July 2001.

Table 6: Production and production capacity information for 2003 for each cell / module manufacturer

	II/Module Inufacturer	Technology (sc-Si, mc-Si, a-Si, CdTe)		(sc-Si, mc-Si, (MW)		production IW at the year 2002)	Additional Information
		· •	Cell	Module	Cell Module		
7.	RWE Schott Solar GmbH, Alzenau	EFG mc-Si	40 (25)	5 (0,5)	43,0	module	RWE Schott Solar is a joint venture between RWE Solutions AG and Schott Glas AG. In this company, founded in october 2002, the two companies have bundled all their terrestric photovoltaic activities, like RWE Solar GmbH, the american ASE Americas, Inc and the american SCHOTT Applied Power Corporation. In spring 2003, the first prduction lione of RWE Schott Solar's SmartSolarFab went into full operation. Until the end of 2004, a capacity of 60 MW solar cells based on the EFG film technology will be realised.
8.	Saint Gobain Glass Solar GmbH, Aachen	mc-Si		<1 ?(1,0)			Former Vegla, produces PV modules for integration in buildings (glass-glass, isolating glass).
9.	Shell Solar GmbH, Gelsenkirchen	sc-Si mc-Si	9 (9,0)	0 (5,0)	13 (10,0)		Shell Solar is producing mc-Solar cells in Gelsenkirchen. In 2001, Siemens Solar and Shell Solar has merged to a joint venture, the Siemens & Shell Solar GmbH. In early 2002 Shell Solar has taken over all shares of Siemens (34%) and the utility Eon (33%) and the company was renamed in Shell Solar.
10.	Solara AG, Hamburg			6 (3,0)			The main distributor of Photowatt in Germany started a production line in Wismar and produced the first modules in 2001. The capacity is planned in several steps up to 24 MW.
11.	Solar Fabrik GmbH, Freiburg	sc-Si sc-Si		8,5 (7,2)			Founded in 1993, started PV module production (75W-115W) in 1997 in co-operation with Astropower. Produces modules since 1999 in a new factory designed and built according to ecological regulations.
12.	Solar Factory GmbH			7			

Cell/Module manufacturer	Technology (sc-Si, mc-Si, a-Si, CdTe)	Total Proc (MW)	luction	<u>Maximum</u> production capacity (MW at the end of the year 2002)		Additional Information
	-	Cell	Module	Cell	Module	
13. Solarnova GmbH, Wedel	sc-Si, mc-Si		0,9 (1,0)			Founded in 1996. Developed and erected a special production line for custom made modules (50W-100W) and produces since 1998 in a new building.
14. Solarwatt Solar- Systeme GmbH, Dresden	misc. sc-Si and mc-Si		7,4 (4,0)			Founded in 1993, started production of custom made PV modules (28W, 55W -110W) in 1997. Specialized in all kinds of geometric forms and colours and roof tiles.
15. SOLON AG, Berlin	Misc. Sc-Si mc-Si		11 (6,0)			Founded in 1997, produces multicrystalline modules (50W-200W). Acquired SolarWerk in 2000. Extension of the capacity planned by 2002.
16. S.M.D. Solar- Manufaktur Deutschland GmbH			13 (1,5)			
17. Sunways A.G. Konstanz	'power cells' mc-Si	6,7 (5,0)		7,0		Production of mc-Si solar cells and, since 1999, of semi- transparent so-called power cells.
18. Sunset Energietechnik			2,2			
19. Webasto Systemkomp. GmbH, Stockdorf	Sc-Si mc-Si		1,5 (1,0)			Specialized in manufacturing of flexible PV modules (26W and 50W) and for various applications, e.g. sun roofs for cars and caravans, etc.

Cell/Module Technology manufacturer (sc-Si, mc-Si, a-Si, CdTe)		Total Production (MW)		<u>Maximum</u> production capacity (MW at the end of the year 2002)		Additional Information
	· · ·	Cell	Module	Cell	Module	
2021. Others:			2,23 (1,52)			
TOTALS		110 (57)	75 (39)	135 (94)		
1. AnTec Solar GmbH, Rudisleben	Cd-Te		5 (1,5)		10,0	Since 1998 installation of a production line in so-called Advanced Thin-Film Technology (ATF). Since September 2001 production in small quantities. Due to insolvency
 RWE Schott Solar GmbH PST, Putzbrunn 	a-Si		2 (1,0)		3,0	 production was temporary closed. AnTec has found a new investor. Phototronics is a subsidiary of RWE Schott Solar. Production and R&D of amorphous thin-film cells and modules. Developed modules with a-Si/a-SiGe tandem cell structures.
 Würth Solar GmbH, Marbach am Neckar 	CIS		0,4 (0,15)		0,35	Founded in 1999. Started a small pilot production line for CIS thin-film cells/modules in 2001.
TOTALS			7,4 (2,65)			

Future plans for PV modules and solar cells production

Most of the German PV cell or module producers plan to extend their production lines or to increase their output in 2004.

Two large German companies are on the way to become full integrated solar factories, combining the most important steps of the module production under their roofs. The aim of this strategy is to get more independence in constantly varying markets.

 SolarWorld in Bonn and Freiberg (with the subsidiary companies Deutsche Solar, Deutsche Cell, Solar Factory) plans to extend the capacities of their wafer, cell and module production at their locations in Freiberg and Gällivare/Sweden until 2007 as follows: Wafers: up to 240 MW Cells: up to 120 MW Modules: up to 120 MW

In addition the Deutsche Solar intends to produce 'solar silicon' economically in co-operation with the US company GT Equipment Technology and the German DEGUSSA.

- RWE Schott Solar will extend their "SmartSolarFab" production with two new cell lines in Alzenau and add about 40 MW production capacity for cells and modules. First outputs will be realised in spring 2005.

Q-Cells AG, Thalheim, will extend their production of solar cells to 75 MW in 2004, according to the ambitious plans for 2005 a production capacity of 200 MW is planned.

PV module prices

The PV module prices are varying in a wide range depending on the type of application. It is evident that PV modules, custom-made for special building integrated projects or solar roof tiles are much more expensive than standard PV modules. The "real" prices the customer has to pay for his specific project are hard to determine. That's why we rely on the annual PV-module survey of the German journal 'Photon'. These prices are usually too high but it is possible to see the development of the prices over the years.

As in the past, in 2003 the trend was clear: Module prices dropped about 10%. Reason for this is the competition by foreign producers .

Reported module prices were in the range of 2,5 €/W to 9,7 €/W.

Thin-film modules still play no important role in the market

3.2 Manufacturers and suppliers of other components

According to a market survey of available inverters (Photon issue 3/2004) 27 manufacturers are offering about 166 inverter types of different sizes for the grid-connected and off-grid applications in Germany. As the inverters differ very much in technology, it does not make sense to give an average price per kVA.

The companies of the German market increased their production output of inverters from 127 MW in 2001 to 165 MW in 2002 and 282 MW in 2003. The percentage of export is unknown. The leading German manufacturer of inverters, SMA, alone produced 148 MW.

As an actual trend the German inverter manufacturers get new competititors: An increasing number of foreign companies are trying to get into the German market.

3.3 System prices

In Table 6 turnkey prices (excluding VAT) in EURO per W are given for the most installed reference system in Germany, a typical roof mounted 2 - 3 kW PV system. The announced figures are the result of the inquiry made by Photon about system prices with an installed capacity in the range of 1 to 5 kW (Photon 4/2003). The trend is obvious: Prices dropped about 10% from 2002 to 2003.

Table 7: National trends in system prices in for a roof mounted 2 - 3 kW PV system

YEAR	1995	1996	1997	1998	1999	2000	2001	2002	2003
Price /kW: €	8 390	7 720	7 060	6 540	6 190	6 540	6 400	5 600	5080

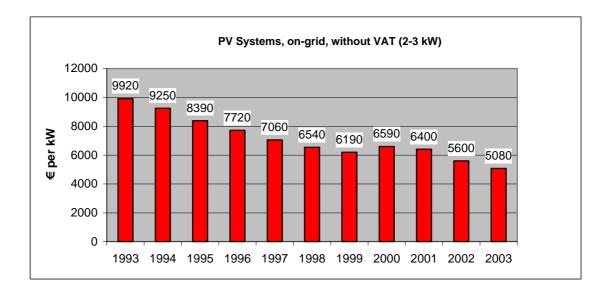


Figure 3: National trends in system prices for a roof mounted 2 – 3 kW PV system

3.4 Labour places

Labour places in different PV sectors can only be estimated based on several publications.

In total a number of about 10 000 to 12 000 full time labour places existed at the end of the year 2003.

4 Framework for deployment (Non-technical factors)

4.1 New initiatives

The German financing schemes, the 100 000 Roofs Solar Power Programme in combination with the Renewable Energy Law (REL), were proven as very well accepted market introduction instruments.

The REL which indicates the priority of renewable energies for the German government applies to all kinds of renewables such as wind, biomass, photovoltaics, water, biogas (dump and sewage) and geothermics. The law aims to double the share of renewables on the electrical power generation in Germany from 5% in 1999 to 10%

in 2010. The medium and long-term goals are to reduce the CO_2 emission and to reach the competitiveness of renewables with conventional energy sources.

The high demand of private and SME PV plant operators and investors was suggesting to extend the programme by lifting up the 350 MW limit. In June 2002 the German Parliament decided to set the limit at 1000 MW. This decision provides certainty in planning their investments for the whole PV sector.

While the pay back rate is decreasing annually by 5% from the first rate of $0,51 \in \text{per}$ kWh fed into the grid in 2000 and 2001 ($0,457 \in \text{per}$ kWh in 2003), the industry is faced with a real challenge to decrease prices by rationalization measures in the production.

A compensation of the 100 000 Roofs Solar Power Programme running out in 2003 was realised by a modification of the pay back rates according REL in 2004.

4.2 Indirect policy issues

Next to the publication of the guidelines for the '100 000 Roofs Solar Power Programme' the German Government realised the first stage of an ecological tax reform. Prices of fuel oil (2,05 cents per litre), natural gas (0,164 cents per m³), gasoline/diesel (3,07 cents per litre) and electrical power (1,05 cents per kWh, including renewable energies) were increased on 1st April 1999 and four additional steps for increasing followed on 1st January 2000, 2001, 2002 and 2003.

4.3 Standards and codes

The elaboration of standards and codes for PV is performed on the European level (CENELEC) and international level (IEC). The actual list of international standards and codes can be found on the web site: <u>www.iec.ch</u>.

5. The Future

With a growth rate of more than 50% the German PV market has again reached a tremendous growth in 2003 after the stagnation in 2002.

The 100 000 Roofs Solar Power Programme has reached its goals:

- extension of the German PV market 12 MW (1999) => 130 MW (2003)
- cost reduction of more than 20%
- production capacity was created (Wafer, cells, modules, inverters)

With the new Renewable Energy of January 2004 the feed-in tariffs were again improved. This should help to maintain a strong market into the future and gives a certainty for the industry concerning their investments. Now it is the industry's turn to develop cheaper production technologies and to decrease PV module and PV system prices in 5% steps per year as the pay back rates decrease according to the REL.

First evaluations of the PV market development in 2004 show that the growth of 2003 can be reached again this year.

The plans of the industry referring to the expansion of existing and the installation of new production lines are ambitious.

On the increasing PV market the lack of raw materials and the dependence on the waste of electronic grade silicon for the semiconductor industry becomes more and more evident. There are two German initiatives to establish a solar grade silicon factory (joint venture Solar World AG/ Degussa and Wacker Chemie); both are intending to start a pilot production line in 2005.

Annex A Exchange rate

Since the introduction of the new European currency EURO (\in) in most of the European countries, e.g. Germany, the exchange rates between national currencies of those countries are fixed. For the harmonization of the prices in the International Survey Report the official rates could be used:

e.g. 1 € = 1,95583 DEM

All prices in this report are given in €.

Annex B Method and accuracy of data

For a summary of the methods used to gather, process and analyse the data given in the NSR look at the introduction and sector 2.2. The accuracy of the assessed data for the installed power is about +/-10%.