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 2002

Prepared on behalf of
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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 Co-operation 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 members 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. Eight tasks have been established and currently seven are active.

The objective of Task 1 of the IEA-PVPS is to promote and facilitate the exchange and dissemination of information on the technical, economic and environmental 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:

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

Installed PV power: 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').

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

PV system: 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.

Off-grid domestic PV power system: 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'.

Off-grid non-domestic PV power system: 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'.

Grid-connected distributed PV power system: 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.

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

Module manufacturer: 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 off-grid system, the prices associated with storage battery 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).

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

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

Market deployment initiative: 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

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

Performance ratio: 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, Science, Research and Technology

BMWA: Federal Ministry of Economics and Technology

BMU: Federal Ministry of Environment

KfW: Kreditanstalt für Wiederaufbau (The German Development Bank)

DENA: Deutsche Energie Agentur

DtA: Deutsche Ausgleichsbank

FVS: Forschungsverbund Sonnenenergie

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

VDEW: Verband der Elektrizitätswirtschaft (Association of German Utilities)

VDN: Verband der Netzbetreiber, association of the grid operators within the VDEW

DBU: Deutsche Bundesstiftung Umwelt (German Federal Environment Foundation)

REMI: Renewable Energy Market Initiative by IEA-PVPS

German Associations

BEE: Bundesverband Erneuerbare Energien

DGS: Deutsche Gesellschaft für Sonnenenergie

DFS: Deutscher Fachverband Solarenergie

UVS: Unternehmensvereinigung Solarwirtschaft

1 Executive summary

After years of strong PV market growth in Germany, the year 2002 was characterized by a market stagnation on a high level. The additional installed PV power of 83 MW in 2002 was about as large as in 2001, which was less than anticipated.

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 0,481 € for every kWh, which is generated by photovoltaic power plants and fed into the grid (in 2001: 0,51 €/kWh)

remained almost the same as in 2001.

Reasons for the reduced demand were the weak situation of the economy in Germany, the introduction of a new currency, the EURO, and uncertainties about the future support of PV after the elections in September 2002. As a consequence the module prices dropped and the economical situation of some companies got critical.

The Kreditanstalt für Wiederaufbau (KfW) is the responsible governmental authority for granting PV system proposals within the 100 000 Roofs Solar Power Programme. According to the statistics of the KfW, 8,9 MW in 3523 PV plants were accepted for loans in 1999; 36,6 MW for additional 7 824 PV plants in 2000, in 2001 about 76,4 MW in 19 415 PV plants were accepted and 78,3 MW in 15 228 PV plants were confirmed for loans in 2002. Referring to the KfW statistics (31.03.2003), by the end of 2002 about 45 899 PV plants resulting in a total installed power of 199,68 MW in the range of 1 to 120 kW and more were applied and accepted for grants. The average size of the PV plants granted by the KfW increased from 3,9 kW in 2001 to 5,14 kW in 2002.

While the analysis of the KfW database indicates that 20 PV plants in the power range >99 kW with an installed power of 3,05 MW (3,9% of the total granted power in 2002) have been granted in 2002, more than 4,57 MW in 50 PV systems have been granted by the Deutsche Ausgleichsbank (DtA). Besides the KfW, DtA is another governmental authority funding environmental projects. Since the regulations have been modified, the DtA is granting ground mounted plants >100 KW which cannot be funded by the KfW, but by the DtA with higher interest loans (~5% instead of 1,91).

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

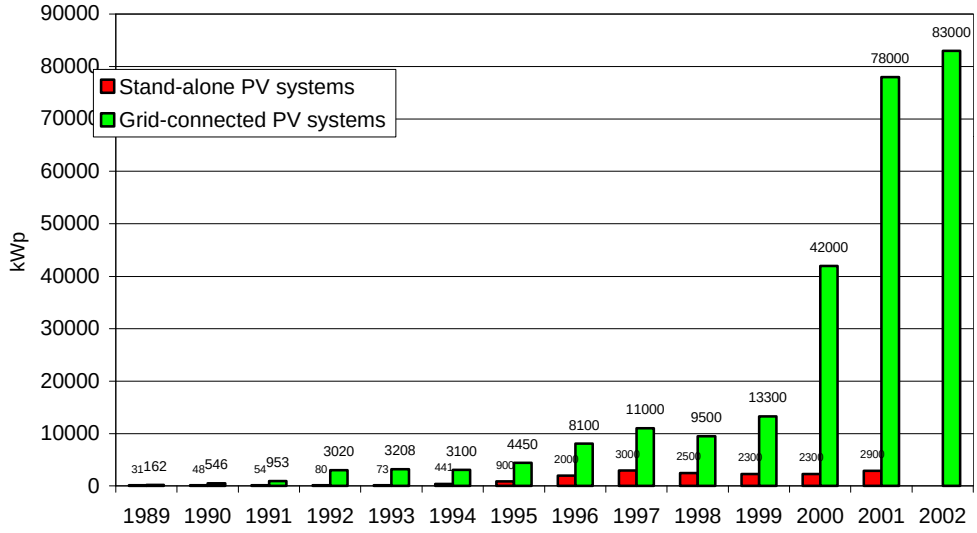

Figure I: Installed PV Module Power for grid-connected and off-grid PV Applications per year from 1989 to 2001.

The actual installed power for 2001 was estimated for grid-connected applications at 83,0 MW. About 7,62 MW of this amount were installed in centralized applications. The accuracy in this case is essentially a question of the temporal assignment.

Figure I shows that the off-grid PV applications are of less importance, whereas grid-connected PV systems were increasing rapidly. The reason is that the new 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.

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 2002, the production of solar cells applying all different technologies amounted to 57,0 MW, increasing from 4,1 MW in 1999, 15,9 MW in 2000, 33,0 MW in 2001. The production capacity reached 94 MW (56 MW in 2001, 33 MW in 2000, 27 MW in 1999). 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 I: Total German Production and Capacity, Export and Import Data of PV Modules

	1994	1996	1998	1999	2000	2001	2002
Total Production	4,4	3,0	6,4	8,8	16,1	29,0	41
Production Capacity	6,4	9,6	24,9	27,0	33,4	56,0	94

The German PV module production including thin film and special PV modules (flexible for car roofs and boats) amounted to 41 MW.

As the German PV module production increased from 2001 to 2002 while the demand almost remains the same, the percentage of German modules used in the 100.000 roofs programme increased. But still about 60% of the modules comes 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 7000 full time labour places existed in the PV industry at the end of the year 2002.

The ***system prices*** dropped about 14% in 2002. The average system price for the key system of a roof mounted PV systems in the power range of 2-3 kW was about 5 600 €/ 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 subsidies in several Federal States (e.g. Nordrhein-Westfalen), which reflects the federal political system
- 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 will support the German PV market at least until the end of 2003, when the 100.000 roofs programme will reach its 300 MW limit. But even after that date the REL 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 we have the 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. For example, PV systems up to a power capacity of 5 kW were funded within the 100 000 Roofs Solar Power Programme by low interest loans (1,91%) up to 6 230 €/kW system costs, above 5 kW the granted amount was limited to 3 115 €/kW in 2002.

The analysis of the granted (grid-connected) applications by KfW (updated 31.03.2003) 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:

Year	number of PV systems	power capacity	average installed
1999	3 522	8 895 kW	2,53 kW
2000	7 824	36 604 kW	4,68 kW
2001	19 325	75 874 kW	3,93 kW
2002	15 228	78 308 kW	5,14 kW

While the number of PV plants decreased from 2001 to 2002 the granted power capacity increased. The average installed power increased significantly.

The analysis of KfW also contains a detailed subdivision of the in 2002 granted PV system into plant sizes:

Subdivision of granted applications into different plant sizes

Plant sizes (kW)	Number of granted plants in 2001	Granted power kW in 2002 (2001)	Granted power 1999 - 2002	Share of total granted power
< 6	12 454 (18 085)	44 332 (55 215)	125 794	61,5 %
6 – 20	2 520 (1 273)	22 686 (11 722)	43 578	21,3 %
20 – 50	232 (198)	6 074 (5 637)	16 617	8,1 %
50–99	36 (36)	2 377 (2 131)	8 596	4,2 %
> 99	20 (22)	3 050 (2 720)	10 005	4,9 %
Total	15 262 (19 614)	78 521 (77 425)	204 592	100,0 %

Remark: These numbers are different to the statistics update from 31.03.2003 and were only used for the subdivision in different plant sizes. It must be noticed that all these numbers only can be rough guide values, because the period between approval and installation can be delayed up to 9 months.

In the table above the grid-connected distributed applications 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 95,1% referring to all PV power granted by the KfW 1999 - 2002.

Only 20 PV plants > 100 kW with a power capacity of 3,05 MW (see table above) were granted by KfW in 2002. Additionally 50 centralized PV-systems were funded by the DtA Deutsche Ausgleichsbank (DtA) with higher interest loans (about 5% instead of 1,91% by KfW). DtA, another governmental authority funding environmental projects, has reported a granted and installed power of 4,57 MW in 2002. As there is no adequate statistics available the installed power of centralized grid-connected applications in 2002 will be estimated at 7,62 MW.

Especially citizen associated companies, commercial enterprises, professional investors and green power utilities had discovered photovoltaics and are installing middle sized PV plants in the range of 50 to 120 kW and larger. In order to get the maximum feed-in tariffs, large PV plants are often divided into separate PV plants with an installed power of 99 kW each. In all cases it is difficult to separate larger PV systems in 'distributed' and 'centralized'. In this report all plants > 99 kW were assigned to the centralized applications.

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 2002 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 (BMWA, BMBF) and their executing institutions (KfW, DtA, BAFA)
- the DBU, the German Federal Environment Foundation
- selected ministries of the 16 federal states, sponsoring PV with additional general market introduction programmes besides the governmental funding. In all federal states the regulations were adapted or the programmes stopped since the nation-wide financing schemes came into force (see Table 2b).
- parent organisations of the utilities (VDEW and VDN)

As in 2001, even in 2002 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 %.

Table 1: The cumulative installed PV power in 4 sub-markets

Sub-market/ application	31 Dec. 1993 kW	31 Dec. 1994 kW	31 Dec. 1995 kW	31 Dec. 1996 kW	31 Dec. 1997 kW	31 Dec 1998 kW	31 Dec. 1999 kW	31 Dec. 2000 kW	31 Dec. 2001 kW	31 Dec. 2002 kW
off-grid domestic	346	373	500	1 100	2 100	2 900	3 450	4 200	6 200	-
off-grid non-domestic	N.A.	413	1 187	2 587	4 587	6 300	8 050	9 600	10 500	-
grid-connected distributed	6 587	9 124	13 063	19 896	28 676	37 300	49 100	89 900	162 000	240 000
grid-connected centralized	1 967	2 530	3 040	4 307	6 527	7 400	8 900	10 100	16 000	20 600
TOTAL	8 900	12 440	17 790	27 890	41 890	53 900	69 500	113 800	194 700	260 600 + non-grid

Note: The cumulative installed power includes power installed before 1992.
The data in Table 1 are rounded.
The assessed accuracy for off-grid applications is at ±15% and for on-grid applications at about ±10% (see annex B).

PV modules with a power of about 83 MW were installed in 2002 in Germany for all grid-connected applications.

Contrary to the end of 2000 it can be supposed that most of the PV systems granted by KfW have been installed in 2002, because the rate to be paid for every kWh, fed into the grid, decreased by 5% from 0,481 € to 0,457 € by January 2003. The inquiry resulted to 83,2 MW installed in all grid-connected applications, about 78,5 MW in the distributed and 4,6 MW in the centralized sector.

2.3 Major projects, demonstration and field test programmes

Since the introduction of the 100 000 Roofs Solar Power Programme (1.01.1999) and the Renewable Energy Law (1.04.2000), 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.

Projects with a broad demonstration effect such as the 'Sun at School' were continued only by the governmental organisation BAFA (Bundesamt für Wirtschaft und Ausfuhrkontrolle), which co-financed the installation of 157 kW with 3 000 € per 1 kW PV plant in 2002.

A similar follow-up programme was realised by the DBU (Deutsche Bundesstiftung Umwelt - German Federal Environment Foundation) with the initiative '300 Parish for Solar Energy' using the important role of the churches to strengthen the public awareness. This programme should be assigned to the demonstration projects, 2 680 kW were installed under these programme 1999-2002.

The main share of the installed power in Germany in 2002 is based on the support of the 100 000 Roofs Solar Power Programme co-financed by several Federal States (see Table 2b).

Table 2a: Summary of major projects, demonstration and field test programmes

Project Date plant start up	Technical data/Economic data	Objectives	Funding	Remarks
Demo-Progr. 300 Parishs for Solar Energy 1999 – 2001	622 grid-connected PV plants, installed power 2 680 kW	To contribute to the extended use of solar energy using the important role of churches. To obtain experience with g-c PV systems in BIPV (historical build.)	DBU, German Federal Environment Foundation Comb.with REL	Accompanied Monitoring Programme
1,75 MW PV Plant in Sonnen, Bavaria	Solar Park with 18 PV-Systems, 10.500 Modules		REL	
4 MW PV Plant in Hemau, Bavaria	Solar-Park with 40 PV-Systems, 32.740 Modules on the area of a former munitions depot	Commercial project financed by an investment fund Total investment: 20M€	REL	
50 kW PV Plant Marbach Baden-Württemberg	CIS Modules by Würth Solergy	Demo Project on the roof of an Information Center	REL	World´s largest CIS PV plant

Table 2b: Survey of PV funding in 2002 by governmental institutions

Federal Government	Kind of Funding	Name of Programme
BMWA / BAFA	Subsidy: up to 3000 Euro/ installation	Sun at school, general programme
BMWA/ KfW BMWA/ DtA DBU (foundation)	Low interest loan(1,91%) Low interest loan Subsidy	100 000 Roofs Solar Power-Programme Environmental Programme 300 Parishs for Solar Energy
Federal States		
Baden Württemberg	No general funding	
Bayern	No general funding	
Berlin	No information	
Brandenburg	Subsidy for PV plants outside KfW	REN Programme
Bremen	No funding	
Hamburg	No funding	
Hessen	Project support for PV plants outside KfW	
Mecklenburg-Vorp.	No funding	
Niedersachsen	No general funding	
NRW	2 kW 750 €/kW for BIPV 1200 €/kW	REN Programme, about 70% co-financed by other sources (100 000 Roofs, etc.)
Rheinl.-Pfalz	No general funding	Sun at school
Saarland	No funding	
Sachsen	No funding	
Sachsen-Anh.	No general funding	
Schleswig-Holstein	No funding	
Thüringen	Subsidy 40% up to 153 000 €	Market introduction programme, Combination with 300 Parishs for Solar Energy

Remarks: Table 2b provides a general idea of the PV funding in 2002 within the 16 Federal States. After the '100 000 Solar Roofs Programme' and the REL came into force the funding conditions were modified or the financial support was totally cancelled.

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.

Following these goals the German governmental policy is directed on funding basic research in new solar cell technologies and innovative production technologies for solar cells. Examples:

Crystalline silicon: Crystalline silicon is still the most important material for manufacturing solar cells. Today, emphasis is placed on efficient manufacturing techniques. In 2002, new R&D activities were focused on:

- Co-operate R&D project ASIS – **A**lternative **Si**licon Materials for **S**olar Cells
- Development of a progressive technology for EFG Silicon ribbons and solar cells
- Expert circle SOLPRO – Innovative and economic production processes for Silicon based PV modules

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 2002 the support from the Federal Ministries (BMBF, BMWA) for R&D on PV projects amounted to about 23,6 M€, after 39,1 M€ in 2000 and 31,4 M€ in 2001. 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.

As the subsidy within the "Parish for Solar Energy" programme was extended and the application period prolonged by the DBU, the number of applications increased from 300 applications at first to about 621 by the end of 2002. The installed capacity within this programme is limited to 6 kW per application, while the budget for

demonstration projects remains on a low level and was only spent by Federal States for special, innovative projects. The incentives for market introduction and general programmes were mainly spent in 2002 by several Federal States (particularly Nordrhein-Westfalen) and KfW, one of the executing institutions of the Federal Government. The support according the REL (0,48 € per every kWh generated by PV) will be paid by all German electrical energy consumers. About 123,452 GWh were estimated by the Verband der Netzbetreiber (VDN) for the feed in energy by PV plants in 2002. This amount is corresponding to about 176 MW and much too low compared with the installed power of about 245 MW grid-connected PV plants.

In the framework of the 100 000 Roofs Solar Power Programme in 1999, 2000, 2001 and 2002 loans with a total amount of 1 068 M€ were confirmed. This amount is corresponding to the proposed budget by the BMU/BMWA of 25,0 M€ (2001: 16,77 M€), but the real cost data are not available.

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. This programme in the modified version of 1st April 2000 guarantees a maximum installed power of 300 MW from 1999 until 2003. By the end of 2002 about 46 000 PV plants with a total power of 200 MW were granted by KfW.

The remaining power to be granted by KfW is provided by 100 MW in 2003. In 2004 the 100.000 roofs programme will not be continued. The support of PV systems with the REL will be continued but the conditions for the future are not yet clear. Thus the industry has some incertainty 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 and 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. But in 2002, after years of strong growth, the PV market in Germany stagnated for the first time. Reasons for the reduced demand were the deterioration of the general economical situation, the introduction of a new currency, the EURO, and some uncertainties about the future support of PV after the elections in September 2002. As a consequence the module prices dropped and the economical situation of some companies got critical.

The development of some of the future plans of the 2001 National Survey Report may highlight the situation in 2002: The announced 12 MW PV module production line near Paderborn in a joint venture of Isofoton with the main distributor in Germany,

Biohaus was not realised. BP Solar has not installed a 20 MW PV module production in Hameln. The 24 MW roof tiles production line in Gelsenkirchen planned by BlueSun-Systems will not be realised. The company BlueSun-Systems became insolvent.

The extension of the production capacity of cells and modules of most German producers in Germany (Solarworld (Deutsche Solar), RWE Schott Solar, ErSol, Solon) was slower than predicted; Shell Solar closed their production in Munich (module) and Helmond (cell and module). AnTec Solar (CdTe cells) became insolvent.

Nevertheless, two large companies on the German PV market

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

are still 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 2002 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 2002, the wafer production capacity amounted to 87 MW .

Solar cells

Five companies have produced solar cells in 2002 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 2002 remains constant 9 MW.

The "Newcomer" Q-Cells in Thalheim produced 9 MW mc-Si solar cells in 2002.

RWE Schott Solar, Alzenau, produced EFG and mc-Si solar cells with a capacity of 24 MW and RWE Schott Solar, PST, in Putzbrunn produces a-Si cells with a capacity of 1 MW.

Shell Solar Deutschland, has reached an output of 9 MW mc-Si cell production on their line in Gelsenkirchen in 2002.

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 5 MW in 2002.

At the end of 2002, the total solar cell production amounted to 57,0 MW (31 MW in 2001, 15,9 MW in 2000).

It is expected that the capacity will be extended to more than 125 MW in 2003.

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 2002 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).

According to the results of the inquiry of the German solar cell and PV module manufacturers in 2002, 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 to 42 MW in 2002.

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 2,65 MW
- 12 companies producing more than 1,0 MW per year. Their total production output in 2001 amounted to 40,5 MW or 96% of the total production.

In 2002, the total solar module production amounted to 42,0 MW. It is expected that the capacity will be extended to 95 MW in 2003.

Table 4: Production and production capacity information on the main module manufacturers for the year 2002

Cell/Module manufacturer	Technology (sc-Si, mc-Si, a-Si, CdTe)	Total Production (MW)		Maximum production capacity (MW at the end of the year 2002)		Additional Information
		Cell	Module	Cell	Module	
1. Alfasolar Vertriebsgesellschaft mbH			2,5			
2. Ersol Solar Energy GmbH Erfurt	mc-Si	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.
3. Flabeg Solar International GmbH, former Pilkington, Köln	Sc-Si/ Ersol mc-Si/ RWE Sol.		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 production.
4. GSS GmbH and IPEG GmbH, Löbichau	mc-Si/ Ersol, RWE Solar/ AstroPower and Shell Solar		2,5			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.
5. Q-Cells AG, Thalheim	mc-Si	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.

Cell/Module manufacturer	Technology (sc-Si, mc-Si, a-Si, CdTe)	Total Production (MW)		Maximum production capacity (MW at the end of the year 2002)		Additional Information
		Cell	Module	Cell	Module	
6. RWE Solar GmbH, Alzenau	EFG mc-Si	25	0,5	43,0		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. By the end of 2002 a cell production capacity of 43 MW (mc-Si and EFG) was installed. Within the next 3 years the cell production capacity shall be extended in 15 MW steps up to 80 MW as part of an integrated 60 MW solar factory with the production of wafers, cells and modules. PV modules were produced (95W-260W) in commission by several German companies.
7. Saint Gobain Glass Solar GmbH, Aachen	mc-Si/ Ersol and RWE Solar		1,0			Former Vegla, produces PV modules for integration in buildings (glass-glass, isolating glass).
8. Shell Solar GmbH, Gelsenkirchen	Sc-Si mc-Si	9,0	5,0	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.
9. Solara AG, Hamburg			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.
10. Solar Fabrik GmbH, Freiburg	sc-Si sc-Si		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.
11. Solarnova GmbH, Wedel	sc-Si, mc-Si		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.

Cell/Module manufacturer	Technology (sc-Si, mc-Si, a-Si, CdTe)	Total Production (MW)		Maximum production capacity (MW at the end of the year 2002)		Additional Information
		Cell	Module	Cell	Module	
12. Solarwatt Solar-Systeme GmbH, Dresden	misc. sc-Si and mc-Si RWE Solar and Sunways		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. In 2001 a new 3 MW production line was installed,
13. SOLON AG, Berlin	Misc. Sc-Si /Solartec mc-Si/Q-Cells Sunways, Ersol		6,0			Founded in 1997, produces multicrystalline modules (50W-200W). Acquired SolarWerk in 2000. Extension of the capacity planned by 2002.
14. S.M.D. Solar-Manufaktur Deutschland GmbH			1,5			
15. Sunways A.G. Konstanz	'power cells' mc-Si	5,0		7,0		Production of mc-Si solar cells and, since 1999, of semi-transparent so-called power cells.
16. Webasto Systemkomp. GmbH, Stockdorf	Sc-Si mc-Si		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.
17. -21. Others: ASS Automative, Sunset Energietechnik, SunWare Solar-technik, Sunovation, Solarc			1,522			
TOTALS		**57**	**39**	**94**		

Cell/Module manufacturer	Technology (sc-Si, mc-Si, a-Si, CdTe)	Total Production (MW)		Maximum production capacity (MW at the end of the year 2002)		Additional Information
		Cell	Module	Cell	Module	
1. AnTec Solar GmbH, Rudisleben	Cd-Te		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 production is closed now. Currently looking for a new investor.
2. RWE Schott Solar GmbH PST, Putzbrunn	a-Si		1,0		1,0	Phototronics is a subsidiary of RWE Solar. Production and R&D of amorphous thin-film cells and modules (32W) is underway. Developed modules with a-Si/a-SiGe tandem cell structures. Produces modules for OEM-applications. An extension of the cell production capacity to 3 MW is planned for 2003.
3. Würth Solar GmbH, Marbach am Neckar	CIS		0,15		0,35	Founded in 1999. Started a small pilot production line for CIS thin-film cells/modules in 2001. An extension to 1,3 and to 10,0 MW is planned.
TOTALS			**2,65**			

Future plans for PV modules and solar cells production

Two large German companies with high financial background 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) has built a new cell plant in Freiberg and will produce 22 MW mc-Si cells in 2003. In addition they will also raise their module production capacity at two locations: In Gällivare/Sweden where Gällivare PhotoVoltaic AB, another part of SolarWorld, has extended their module production capacity to 20 MW, while Solar Factory in Freiberg plans to build a 15 MW module production in 2003. The wafer production line of Deutsche Solar will be extended from 32 MW to 100 MW in 2003. 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 at a DEGUSSA plant in Antwerpen.

- RWE Schott Solar proceeds with the installation of a new 60 MW integrated cell and module and a 10 MW EFG wafer production line in Alzenau. The building measures started in May 2002. RWE Solutions and Schott Glas have fusioned their PV activities in a joint venture. The new company is called RWE Schott Solar GmbH.

Most of the German PV cell or module producers (Ersol, Q-Cells, PV Silicon, Sunways and many others) plan to extend their production lines or to increase their output in 2003. If these plans become reality or have to be revised like in 2002 depends on the market situation in 2003.

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.

In 2002 the trend was clear: Module prices dropped significantly. Reasons for this were the political and economical situation in Germany and the growing competition by foreign producers.

Reported module prices were in the range of 3,04 €/W to 13,74 €/W, while the usual price for European producers was in the range of 5,50 €/W to 7.50 €/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 3/2003) 17 manufacturers are offering about 175 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. In the 1-10 kVA e.g. range the prices vary from 525 – 1280 Euro per kVA (without VAT).

The companies of the German market increased their production output of inverters from 127 MW in 2001 to 165 MW in 2002. The percentage of export is unknown. For 2003 an output of 240 MW is predicted.

Actually the manufacturers report a trend to inverters of the higher power range. For 2003 several companies plan to offer more of these "central" inverters for large PV-systems.

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 14% from 2001 to 2002.

Table 6: National trends in system prices in for a roof mounted 2 - 3 kW PV system

YEAR	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Price /kW: €	**10 230**	**9 920**	**9 250**	**8 390**	**7 720**	**7 060**	**6 540**	**6 190**	**6 540**	**6 400**	**5 600**

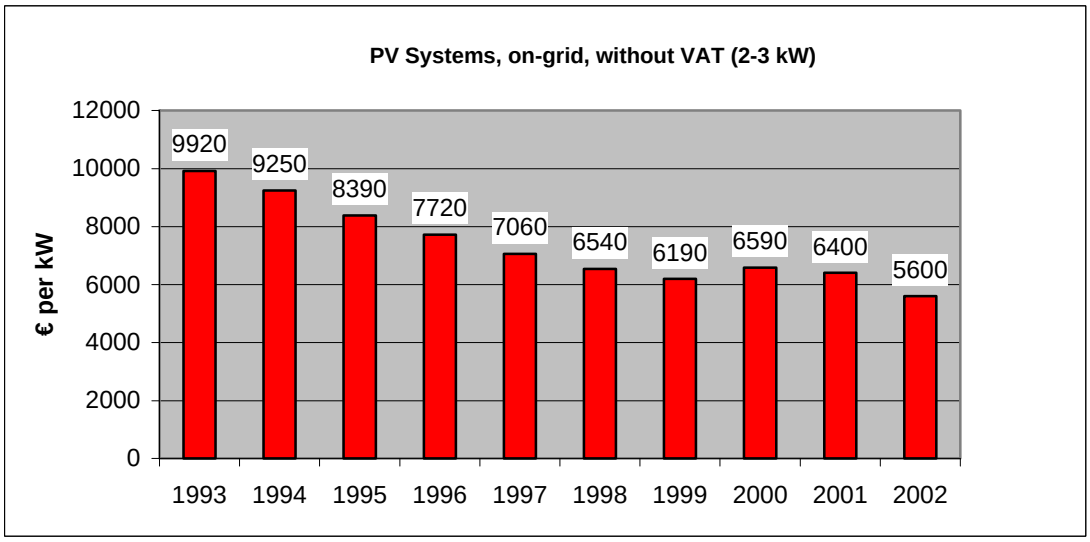

Figure 6: National trends in system prices for a roof mounted 2 – 3 kW PV system

3.4 Labour places

Labour places in different PV sectors are estimated based on a report of the UVS. In total a number of about 7000 full time labour places existed at the end of the year 2002.

About 2 200 employees worked in the German wafer, cell and module industry. Another 1 000 jobs existed in the inverter production. Hard to determine are the jobs in the system and installation companies, because most of the employees don't work 100% for PV. But the number of full time PV labour places in this area is at least as high as the number of places in the PV industry.

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 a very well accepted market introduction instrument.

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, especially in those federal countries with high irradiance, 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 € per kWh fed into the grid in 2000 and 2001, the industry is faced with a real challenge to decrease prices by rationalization measures in the production.

The plans of the responsible KfW are aiming on giving grants for the remaining 100 MW in 2003.

A compensation of the 100 000 Roofs Solar Power Programme running out in 2003 is in discussion by e.g. a modification of the pay back rates according REL. A decision has not yet been made.

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 m^3), 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.

The ecological tax was implemented with the aims:

- to increase the energy consumption by an increase in prices, which should lead to a sustainable diversion of the demand to energy saving and resource protecting products
- to support the renewable energy sources
- to reduce the national insurance contributions.

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: www.iec.ch.

New work initiatives of CENELEC projects are:

PrEN 62124 – PV stand-alone Systems - Design qualification (also IEC work item)

PrEN 62093 - BOS compoenents for PV systems - Design qualification (also IEC item)

PrEN 61730 – Safety Class Definition of PV modules (also IEC work item)

CLC TC WI (007) – Requirements for grid-connection of PV systems

CLC TC82 WI (007) – Inverter Systems for PV systems grid and stand-alone

CLC TC82 WI (008) – Building integrated Solar PV

CLC TC82 WI (009) – Norm Sizes of Solar Modules

EN 60904-9 – PV devices Part 9: Solar simulator performance requirements (existing IEC standard, to be endorsed)

5. The Future

The data of the national survey report show that the growth of the German PV market has reached a stagnation on a high level in 2002. The 100 000 Roofs Solar Power Programme is running as expected and will reach its aim at 300 MW PV installations 2003. This programme in combination with the REL (see chapter 4.1) has set the framework and the benchmark figures for the development of the PV market in Germany for the last years.

First evaluations of the PV market development in 2003 show that after the stagnation in 2002 a market growth of 25% can be reached again this year.

The plans of the industry referring to the expansion of existing and the installation of new production lines (summarized in chapter 3.1) are ambitious.

The certainty for the industry concerning their investments was set by the German parliament in June 2002 raising the 350 MW limit of REL to 1 000 MW. 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. The aim is to become more and more competitive to other energy sources.

In the centre of attention will be the further development of the applications in the framework of the 100 000 Roofs Programme (until the end of 2003) and the REL. The governmental authorities must be successful in long term balancing the demand and the supply side. This will be essential for the decrease in prices. Stop and go situations for the supply demand must be avoided.

The future of PV generated power will considerably depend on the success of the steadily growing number of PV plant operators of all sections: private; SMEs, green power suppliers, associated companies, investors. For this reason new customers have to be acquired and new investment strategies have to be developed.

Other signs for the development of a steadily increasing autonomous PV market and its growing importance are the increasing number of PV companies going public and the edition of environmental funds including PV projects.

On the increasing PV market the lack of raw materials and the dependence on the waste of electronic grade silicon for the semiconductor industry became more and more evident, especially by increasing prices.

However, it is a logical consequence that some initiatives were published to establish a solar grade silicon factory. The Solar World owner of the wafer producer Deutsche Solar and the chemical company Degussa started a joint venture in May 2002. Both companies are intending to start a pilot production line in 2005. Wacker Chemie a German semiconductor company is also involved in solutions to produce solar grade raw materials.

Annex A Exchange rate

Since the introduction of the new European currency EURO (€) 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%.