

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
2007**

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

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i Foreword

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 nineteen participating countries are Australia (AUS), Austria (AUT), Canada (CAN), Denmark (DNK), 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 and the European Photovoltaic Industry Association are also members.

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. Ten tasks have been established and currently six are active. Information about these tasks can be found on the public website www.iea-pvps.org. A new task concerning PV environmental safety and health is now being developed.

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 Definitions, symbols and abbreviations

<u>BMU</u> :	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
<u>BMBF</u> :	Federal Ministry for Education and Research
<u>KfW</u> :	Kreditanstalt für Wiederaufbau (The German Development Bank)
<u>EEG</u> :	Renewable Energy Sources Act (Erneuerbare Energien Gesetz)
<u>DBU</u> :	Deutsche Bundesstiftung Umwelt (German Federal Environment Foundation)
<u>BSW</u> :	German Solar Industry Association

1 Executive summary

The support of renewable energies by the German Federal Government follows the general guiding principles for energy policy namely security of supply, economic efficiency and environmental protection.

Concerning climate protection, the aim is to ensure that all measures are affordable and keep pace with the economic development. For this reason, the German government adopted in December 2007 a package implementing an integrated energy and climate programme which comprises a number of proposals dealing for examples with energy efficiency and renewable energies in the electricity and heat sectors as well as transportation [1].

Moreover, the integrated energy and climate programme also promotes Germany as an industrial and investment location. Through improved efficiency and the use of renewable energies a lower consumption of coal, oil and gas in the transport, heating, hot water and electricity sectors and thus a reduction of Germany's dependence on energy imports will be accomplished.

For the electricity sector the Federal Government set a national target for renewable energies of 12.5 % by 2010 and 20% by 2020. While in 2000 a share of 6.3% for renewable energies was assessed, in 2006 already 11.5 % were reached [2]. For 2007 a share of around 14% is expected which means exceeding the 2010 target already now.

Photovoltaic (PV) adds to this development. From the currently installed PV capacity one can estimate a share for PV of roughly 3 % of the renewable power generated in Germany, see figure 1. Driven by the Renewable Energy Sources Act (EEG), PV still shows an impressive development. Additionally, PV has become a real business with noticeable employment and turnover.

The following tables show the impressive development in the booming PV market in Germany and the governmental support in R&D.

Installed PV Power

New installed (power)	1100 MWp
Total installed power	~ 3.800 MWp
Total number of installed systems	430.000

Source: BSW, April 2008

Cost and prices

Turnkey Prices of Typical PV Applications (VAT excluded (19%) , net, prices rounded)

1 – 2 kWp:	5.200 €/kWp (off-grid / grid connected)
2 – 5 kWp:	4.800 €/kWp (usually grid connected)
5 - 10 kWp:	4.400 €/kWp (usually grid connected)

10 -50 kWp: 4.300 €/kWp (usually grid connected)

Source: Photon 3/2008

PV Production

Production of cells	842 MWp
Production of wafers	415 MWp
Production of feedstock silicon	8000 t
PV power generation	~3.000 GWh

Source: BSW, April 2008

Budget for PV

R&D budget for PV projects by BMU	32,1 Mio. €
R&D budget for PV projects by BMBF	12,4 Mio. €

Source: BMU

Market data

Turn-over PV industry	~5,7 bill. €
Export quota	43 %
Foreign purchases	2,5 bill. €
Labour places	42.600
• Handicraft: 47 %	
• Wholesale: 7 %	
• Industry: 46 %	

Investment in production capacity	~1.863 Mio. €
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Source: BSW, April 2008

2 The implementation of PV systems

2.1 Applications for photovoltaics

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. Differentiated statistics broken down by applications are not available. Compared with 2006 there is a stable and slow increasing request for stand alone systems. First estimates indicate that in 2007 around **3,5 MW** were installed.

Grid-connected applications

The German funding strategy favours the installation of grid-connected PV power systems. Therefore, grid-connected rooftop systems and large PV power plant are further on dominating the market.

BSW (Bundesverband Solarwirtschaft – the German Solar Industry Federation) published in April 2008 the new installed capacity of around 1100 MW for grid-connected systems. That means in total about **3,8 GWp** MW installed capacity by around 430.000 PV power systems.

2.2 Total photovoltaic power installed

Table 1: The cumulative installed PV power in 2 sub-markets.

Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Off-grid	0,2	0,3	0,7	1,6	3,6	6,6	9,1	11,4	13,7	16,6	20	23	26	29	32	35,5
Grid-connected	5,4	8,6	11,7	16,1	24,2	35,2	44,7	58,0	100,0	178,0	258	408	1008	1897	2727	3800

Last year the capacity installed was a topic of discussion in Germany due to different statistical methods. Meanwhile, the data provided by the BSW and the analysis of the Photon Magazine seem to converge. Photon published in 3/2008 a new installed capacity of 1.300 MWp. The dilemma is based on the fact that the high number of installations makes it difficult to track each single system.

As last year for reasons of consistency, we take the figures of BSW as the official ones.

In addition to the market of grid connected systems, there is a stable request for stand alone systems. First estimates indicate that in 2007 around **3,5 MW** were installed mainly for industrial applications as the automotive sector, traffic signals etc.

2.3 PV implementation highlights, major projects, demonstration and field test programmes

Since 2004, Germany is the country with the highest annual PV installation world-wide. This remarkable development is based on the following measures in the area of market introduction:

The “Renewable Energy Sources Act (EEG)” rules the input and favourable payment of electricity from renewable energies by the utilities. In order to stimulate price reduction, the tariffs for new installed PV systems drop currently year by year by 5%. Table 1 shows the development of the basic PV tariff. The rates are guaranteed for an operation period of 20 years.

Table 2 - Development of the basic PV feed-in tariff of the EEG

	2003	2004	2005	2006	2007	2008
Tariff* (Ct/kWh)	46.0	57.4	54.5	51.8	49.2	46,75

* For rooftop- systems smaller than 30 kW; for bigger systems there are lower tariffs; façade integrated systems get a bonus of 5 Ct/kWh.

For 2009 an amendment of the EEG is under discussion. Current plans foresee the introduction of another system class, namely rooftop systems bigger than 1 MW. The feed-in-tariff may be lowered in 2009 by 1 Ct/kWh generally and the depression rate may rise from 5% to 7%. The Federal Parliament will take a decision on the EEG in the first half of the 2008.

At the end of 2003 the “100 000 Rooftops Solar Electricity Programme” terminated. The support of PV systems by soft loans is maintained by the programme “Solar Power Generation”. Under this programme in total 43 000 loans representing a total volume of 338.1 MW equivalents to 1 335 MEUR investments were granted since 2005. In 2007 alone, 101.3 MW were supported.

Other measures like programmes of the Federal States (Länder) and the Federal German Environmental Foundation (DBU) are designed for a local or an application specific support of PV. Moreover, a number of utilities have launched initiatives to build PV-demonstration and pilot systems or to provide advice and information.

2.4 Highlights of R&D

The supply with Silicon is still an important topic for the PV industry. Two German companies, namely Wacker Chemie AG and Joint Solar Silicon, are currently developing alternative production methods for solar silicon. Both processes promise a more efficient manufacturing route and thus energetic and economic advantages.

A co-operative research project between industry and research institutes aims for a minimisation of the kerf-loss of the wafering process. By reducing both the wafer thickness and the sawing gap to 100 µm a cost reduction of 20% to 50% is expected. The projects results will be transferred into production from 2012 on.

Recent developments from the semiconductor industry will be applied to solar cell manufacturing processes in a project of the Fraunhofer ISE. Higher cell efficiencies are within reach when new concepts for light trapping and the conversion of photons into charge carriers are used. The focus of R&D on thin film technologies lays currently on silicon and CIS technologies. Especially the transfer of results from different laboratories to an industry relevant scale is funded. It is expected that in addition to the PV industry the equipment manufacturers will benefit from these projects as well.

Concerning amorphous / microcrystalline silicon films in 2007 a co-operative project on the improvement of TCO layers (Transparent Conductive Oxides) was started. Two research institutes and four PV companies are participating. Additionally, four running activities in the field of CIS technologies address different production routes of different industrial partners.

The next generations of PV inverters will not only allow a secure connection of PV systems to the grid but also offer additional items such as improvement of power quality and advanced supply security. On the background of higher numbers of PV systems on the grid concepts dealing with fault ride through capabilities and cost of ownership receive higher weight. The BMU funds a number of industrial projects dealing with these issues.

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

The new 5th Energy Research Programme is designed to be valid for the period from 2006 to 2008. Under this programme, an open call for tender was released in 2006. Concerning PV, the call addresses five focal points:

- Silicon feedstock and wafer technology, especially the production of solar silicon, reduced material consumption and the development of new cell and module concepts.
- Thin film technologies, especially transfer of concepts and processes into an industrial environment, optimisation of processes considering reduction of costs and investigation of degradation processes aiming for long term stable structures.
- System technology, especially for decentralised grid structures, adaptation to future module generations and standardisation of island systems for global applications.
- Alternative concepts, which are both suitable for power applications and feasible for industrial production.
- Cross-cutting issues like enhancement of the lifetime of all system components, avoidance of materials, which are harmful to the environment, reduction of energy usage in the production and recycling.

In order to provide these targets with concrete goals, a R&D roadmap was developed by representatives from industry and research institutes. The roadmap puts emphasis on a stable decrease of the costs of electricity from PV. It demands the need for an efficient consumption of raw materials, especially of silicon, as well as higher efficiencies in general, long-term stability of all system components and innovative production technologies.

In general, the federal PV R&D strategy is designed to support the German PV industry to reach, maintain and extend their leadership in all relevant disciplines. Therefore, key-projects in the areas silicon wafer technology, thin-film concepts and system technologies are funded. In 2007 the BMU support for R&D projects on PV amounted to about 32.1 MEUR shared by 140 projects in total (Fig.1). The distribution of the budget shows that one focal point still is on wafer based silicon technologies (57% of the budget). The second centre of attention lies on thin-film technologies (32%). The development of system technology (7%) and alternative technologies like organic PV and concentrating PV (4%) are funded as well, see fig. 1. In addition to the BMU grants, the BMBF provides funds for the development of PV technologies as well; currently 5 network projects with 29 participants are supported with a total amount of 12,4 MEUR.

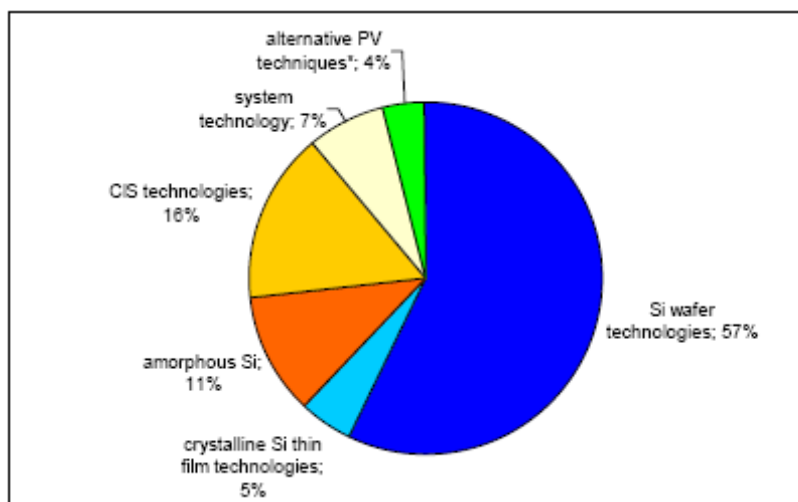


Fig. 1 - BMU funding of R&D in 2007 (* organic & concentrating PV)

Funding Activities of the BMU

In accordance with the PV R&D strategy outlined above, 49 new grants were contracted by the BMU in 2007. The funding for these projects amounts to 41.7 MEUR in total (after 43.4 MEUR in 2006, 32.3 MEUR in 2005 and 29.5 MEUR in 2004).

Funding Activities of the BMBF

In addition to the BMU grants, the BMBF provides funds for the development of PV technologies as well. In summer 2007, the BMBF launched two calls: □ A joint initiative of BMBF and industry is addressing the development of organic solar cells. From 2008 on, 360 MEUR will be available for this type of solar cells. Networks aiming for the development of thin-film solar cells are dealt with by the second call. Emphasis will be put on topics like material sciences including nanotechnology, new experimental or analytical methods and the usage of synergies with other fields of research like microelectronics or bionics. In both cases decisions on funding will be taken early in 2008.

3 Industry and growth

3.1 Production of feedstocks, ingots and wafers

The German PV industry experienced a period of strong growth over the last years. Despite the fact that some investments are delayed, the range of companies dealing with PV is expanding along the whole value chain. Especially the capacity of thin film production facilities is expected to grow significantly in the near future taking advantage from the current global silicon supply shortage. The production figures given below are based on an analysis of the PV magazine "Photon" and the initiative "Invest in Germany".

Silicon feedstock: Wacker, one of the world largest supplier of silicon for the semiconductor and PV industry, again enhanced its silicon production to 8 000 t in 2007. This is equal to a PV production of approximately 660 MW. An extension to 10 000 t until 2008 is already decided. With Joint Solar Silicon, PV Silicon, Scheuten SolarWorld Silizium and Schmid Silicon Technology additional producers will enter the market in 2008/9 introducing new ways for the production of solar silicon. In total, for 2008 a production of **11.750 t** equal to almost 1 000 MW is expected.

Wafer production: The total production of wafer amounted to 415 MW in 2007. The main supplier of silicon wafers is still Deutsche Solar AG in Freiberg. The company produced approximately 250 MW of mono and multicrystalline wafers. Besides Deutsche Solar there are two further Germany based wafer manufacturers: PV Silicon at Erfurt and ASI at Arnstadt. It is estimated that both companies together sold up to 125 MW in 2007. Silicon ribbons are produced by Wacker Schott Solar (EFG-ribbon) in Alzenau and EverQ (String-ribbon) in Thalheim. From 2008/9 on two other companies will start production, namely Conergy in Frankfurt (Oder) and Q-Cells in Thalheim. It is estimated that at the end of 2008 a total wafer production capacity of around 1 300 MW will be accomplished.

Solar cell production: The cell production in Germany shows a steady growth. Starting from 58 MW in 2002 the production **achieved more than 800 MW in 2007**. Currently, nine companies are engaged. These are Deutsche Cell in Freiberg, ErSol Solar Energy in Erfurt, EverQ and Q-Cells in Thalheim, Scheuten Solar in Gelsenkirchen, Schott Solar in Alzenau, Solarwatt Cells in Heilbronn, Solland Solar Cells in Aachen/Heerlen (NL) and Sunways in Konstanz and Arnstadt. With Conergy and Arise Technologies Corp. (Bischofswerda), a Canada based company, ready to start production in 2008 an increase in production capacities to 1 250 MW in 2008 seems possible.

Solar modules: The production of solar modules grew again. After assembling of 40 MW in 2002 the output of **wafer based** modules reached **875 MW** in 2007. Because of the ongoing strong demand for modules, many manufacturers are aiming for further production extensions. The biggest module manufacturers are planning to end up with a production of around 1 000 MW in 2008 alone.

Thin-film technologies: In addition to the silicon wafer activities, there is an increasing number of companies investing in thin-film production lines. In 2007 there was a production of around **94 MW**, namely of silicon technologies (6 MW from CSG Solar, Brilliant 234 and SCHOTT Solar), CIS (16 MW mainly from Odersun, Sulfurcell and Würth Solar) and CdTe (70 MW from First Solar and Calyxo). This is a remarkable increase of thin film production when compared to the activities in previous years, which were on the level of 10 MW. For

the coming years, further growth is expected. For 2008 on a production of more than 250 MW seems likely:

- CSG Solar is going to double its production capacity to 20 MW.
- Brilliant 234, Ersol Solar Energy, Inventux Technologies, Malibu, Schott Solar, Signet Solar and Sunfilm AG announced to establish (additional) production capacities of amorphous / microcrystalline silicon modules until the end of 2008.
- Avancis (former Shell Solar), Global Solar Energy, Johanna Solar Technologies, Nanosolar Inc., Odersun, Sulfurcell Solartechnik and Würth Solar are going to invest in CIS technologies. Together, a production of around 50 MW could be possible during 2007.
- First Solar and Calyxo will increase the production of CdTe modules aiming for a production of 150 MW and 5 MW respectively.

Besides the manufacturing of wafers, cells and modules, the production of **inverter technology** shows impressive growth rates. For 2007 a production of more than 684 MW was published by Photon

In addition to the PV industry **PV equipment manufacturers** supply tools for every step of the PV value chain. The initiative "Invest in Germany" lists 44 companies covering the range from equipment for ingot/wafer production to module turnkey lines.

In Conclusion, the German PV industry is not only a fast growing industry but is also offering innovative products along the whole value chain. During the last years, equipment and production companies became the most experienced ones world-wide. More and more companies are entering into the business making PV to a real opportunity for employment and business in general: Today, around 10000 companies employing 42 000 workers are producing.

Table 3: Production and production capacity information for the year for silicon feedstock, ingot and wafer producers in 2007 (Photon 1/2007)

Producers	Process & technology	Total Production	Maximum capacity	production	Product destination ?	Price?
Silicon feedstock						
Wacker-Chemie	Silicon feedstock	8.000 t		10.000 t/year		
Deutsche Solar AG (Solarworld)	mc-Si ingots	?		?		
PV Silicon AG	sc-Si ingots.	?		?		
WAFER						
		<i>MW</i>		<i>MW/year</i>		
ASI Industries	sc-Si wafers	55		120		
Conergy	mc-Si wafers	0		60		
Deutsche Solar AG (Solarworld)	mc-Si wafers	250		270		
EverQ GmbH	mc-Si wafers	40		100		
PV Silicon	sc-Si wafers	70		?		

Source: Photon, 1/2007

3.2 Production of photovoltaic cells and modules

Table 4: Production and production capacity information for the year 2006 for each manufacturer

Cell/ Module manufacturers	Technology	Total Production (MW)			Maximum production capacity (MW/yr)		
		Cell	Module	Concentr.	Cell	Module	Concentr
1. Aleo AG			88			88	
2. ASS Automotiv Solar Systems GmbH			8			12	
3. Arise Technologies Deutschland GmbH		0			0		
4. Conergy	mc-Si	0	20		275	250	
5. Deutsche Cell GmbH, Freiberg	mc-Si	100			166		
6. Ersol Solar Energy GmbH Erfurt	mc-Si	55			180		
7. EverQ GmbH	string-ribbon, mc-Si	40	40		100	100	
8. GSS GmbH and IPEG GmbH, Löbichau	mc-Si		4,1			16	
9. Heckert B.X.T. Solar GmbH			10			20	
10. Q-Cells AG, Thalheim	mc-Si	389			516		
11. Scheuten Solar Technology	sc-Si, mc-Si	18	55		35	85	
12. Schott Solar GmbH, Alzenau	EFG, mc-Si	70	25		122	35	
13. Schüco international KG			?			5	
14. Solara AG, Hamburg			18,9			30	
15. Solar-Fabrik AG	sc-Si , sc-Si		30			70	
16. Solar Factory GmbH (Solarworld)			100			100	
17. Solarnova GmbH, Wedel	sc-Si, mc-Si		4			10	
18. Solarwatt Solar-Systeme GmbH,	misc. sc-Si and mc-Si		65			100	
19. Solarwatt Cells GmbH		10			16		
20. SOLON AG, Berlin	Misc. Sc-Si ,		115			120	

	mc-Si						
21. Sunways A.G. Konstanz	'power cells' mc-Si	38			46		
22. Sunplastics GmbH	?		0,7			0,7	
23. Sunware GmbH & Co. KG Solartechnik			0,8			2,3	
24. Wulfmeier Solar GmbH			0,1			1	
Thin Film manufacturers							
25. AnTec Solar GmbH, Rudisleben	Cd-Te		0			10	
26. Brilliant 234 GmbH (Q- Cells)	a-Si/ μ -Si		1			8	
27. Calyxo GmbH (Q- Cells)	Cd-Tl		1			8	
28. CSG Solar	cristaline Si		1			10	
29. Ersol	a-Si/ μ -Si		0			40	
30. First Solar	Cd-Te		70			158	
31. Odersun	CIS		1			4,5	
32. Schott Solar	a-Si		4			33	
33. Sulfurcell	CIS		0,5			1,5	
34. Würth Solar GmbH, Marbach am Neckar	CIS		15			15	
Concentrators							
35. Concentrix				0,5			1
36. SolarTec AG				0			5
37. Others:		122	290,4				
TOTALS		842*	968,5	0,5	1456	1333	6

Source: Photon, 1/2007 and 4/2007

* The number of 842 MW total productions for cells is given by BSW. Therefore, the difference between the sum of the single numbers given by Photon and BSW is 194 for the others. Modul production of 875 refers to Photon.

Table 4a: Typical module prices for a number of years

Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004.	2005	2006	2007
Module price(s): Typical	5,98	5,93	5,42	4,91	4,5	4,14	3,73	3,63	3,58	3,53	3,5 - 4,3	3,1 - 3,9	3,0 - 9,6	3,0 - 6,0	3,0 - 5,3	3,0- 4,8
Best price															4,0	3,0

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.

Between 2006 and 2007 there is no remarkable change in prices for modules and installed systems. There is a small tendency to lower prices. An indicative module price in a range from 3,0 to 4,8 €/Wp should represent the main market prices in Germany for 2007. Photon 2/2007 gives a detailed market overview about the German market for solar modules. It is reported a wide range of end prices for modules from 2,35 €/Wp to 8,58 €/Wp (16 % VAT excluded) for single modules (130 – 220 Wp per unit). But most of them are typically in the range of 4,0 to 5,30 €/Wp. There is broad mixture of imported and local manufactured modules. Main module producers for the German market are Asian und German companies using all type of cells available on the world market.

3.3 Manufacturers and suppliers of other components

Besides the manufacturing of wafers, cells and modules, the production of inverter technology shows impressive growth rates. For 2007 a production of 900 MW was estimated.

3.4 System prices

Photon (Photon 4/2007) reported the following average prices (mounted on roof, end price for consumer) for different scales (without VAT, in Germany 19 % in 2007):

Tabel 5: Turnkey Prices of Typical PV Applications (VAT excluded, net, prices rounded)

1 – 2 kWp:	5.200 €/kWp (off-grid / grid connected)
2 – 5 kWp:	4.800 €/kWp (usually grid connected)
5 - 10 kWp:	4.400 €/kWp (usually grid connected)
10 -50 kWp:	4.300 €/kWp (usually grid connected)

The general tendency is that after a remarkable increase from 2003 to 2005 the prices in 2006 are more or less constant with tendency to lower prices in 2007. Photon reported about 8 % from 2006 to 2007. It is assumed that the huge demand for modules determines the selling prices and the effect of cost reduction in production were not referred to the consumers. An indication for this effect on prices can be seen in the record earnings of PV producers and manufactures.

Table 5a : National trends in system prices in for a roof mounted 2 - 5 kW PV system (VAT of 19 % included)

Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Price €/kW	8 390	7 720	7 060	6 540	6 190	6 540	6 400	5 600	5080	5300	5600	5400	5500

Thin-film modules still play no important role in the market, but the German thin-film producers are increasing their capacities.

3.5 Labour places

The BSW estimates that meanwhile around 10.000 companies with 42.000 employees are active in the PV business. More than 80 companies are producer of cells, modules and components. The turnover in 2005 amounted to 5,7 billion EUR.

Labour places in total: 42.600

- Handicraft: 47 %
- Wholesale: 7 %
- Industry: 46 %

No statistical figures for R&D labour places are available, because there are Universities, independent institutes and R&D departments of enterprises.

3.6 Business value

Table 6: German Photovoltaic Market Key Data 2006 (BSW, April 2007)

New installed (power)	1100 MWp
Total installed power	~ 3.800 MWp
Total number of installed systems	430.000
Production of cells	842 MWp
Production of wafers	415 MWp
Production of feedstock silicon	8000 t
PV power generation	~3.000 GWh
Turn-over PV industry	~5,7 bill. €
Export quota	43 %
Foreign purchases	2,5 bill. €
Investment in production capacity	~1.863 Mio. €

Budget for PV

R&D budget for PV projects by BMU	32,1 Mio. €
R&D budget for PV projects by BMBF	12,4 Mio. €

Source: BMU

4 Framework for deployment (Non-technical factors)

4.1 New initiatives

The new 5th Energy Research Programme is designed to be valid for the period from 2006 to 2008. Under this programme, a call for tender was released in September 2006. Concerning PV, the call addresses five focal points: Silicon feedstock and wafer technology, especially the production of solar silicon, reduced material consumption and the development of new cell and module concepts. Thin film technologies, especially transfer of concepts and processes into an industrial environment, optimisation of processes considering reduction of costs and investigation of degradation processes aiming for long term stable structures. System technology, especially for decentralised grid structures, adaptation to future module generations and standardisation of island systems for global applications. Alternative concepts, which are both suitable for power applications and feasible for industrial production. Cross-cutting issues like enhancement of the lifetime of all system components, avoidance of materials, which are harmful to the environment, reduction of energy usage in the production and recycling.

Table 7: PV support measures

	National / Regional (State) / Local
Enhanced feed-in tariffs	Renewable Energy Sources Act (EEG), 49,2 €ct/kwh for PV
Direct capital subsidies	Yes, in some states, REN Programm
Green electricity schemes	Yes, some utilities offer „green electricity“
PV-specific green electricity schemes	no
Renewable portfolio standards (RPS)	No obligations for utilities to obtain a minimum percentage of their power from renewable energy resources
PV requirement in RPS	none
Investment funds for PV	On commercial basis by banks or investment funds dedicated to renewable energies, particularly large solar power plants
Tax credits	None specific for PV, but the regular depreciations by commercial investements
Net metering	yes
Net billing	yes
Commercial bank activities	yes
Electricity utility activities	yes
Sustainable building requirements	Yes, by law for new buildings, there are provisions for energy efficiency

Table 7a: PV support measures

Federal Government	Kind of Funding	Name of Programme
BMU/ KfW DBU (foundation)	Low interest loan (~4,5%) Subsidy	“Solar Power Production” and other environmental and CO ₂ -reduction programmes
Federal States		
Hessen	Project support for PV plants outside KfW	Low interest loans for grid-connected PV systems
Niedersachsen	1. Loans 2. Subsidies for PV systems in some regions (Hannover) 3. Subsidies for PV systems in agriculture	1. Loans for energetical modernization of buildings 2. Max. 7 670 Euro per system
NRW	Subsidies for PV systems	REN Programme
Schleswig-Holstein	Further reduction of interest rates of some KfW programmes (0,15 %)	
Thüringen	Subsidies for PV-systems	

4.2 Indirect policy issues

The German Government finalized the ecological tax reform in 2003. Moreover, since early 2005 an emission trading system is established within the European Union. The Government supports a lot of public relation e.g. internet portals, conferences, events, journals to increase the awareness of renewable resp. PV. Further on there are a lot of associations of industry, handcraft and of a private basis which promote PV in Germany. Main Universities or Instituts in Germany engaged in PV Technologie are in Konstanz, Stuttgart, Hameln und Freiburg.

Links related to PV:

<http://www.bmu.de>
<http://www.solarwirtschaft.de>
<http://www.photon.de/>
<http://www.solarserver.de/>
<http://www.dgs-solar.org/>
<http://www.solarcontact.de/>
<http://www.solarfoerderung.de>
<http://www.sonnenertrag.de/>
<http://www.eurosolar.de/>
<http://www.top50-solar.de/>
<http://www.sonnenertrag.de/>
<http://www.bine.info/>
<http://www.dena.de/>
http://www.bmu.de/files/pdfs/allgemein/application/pdf/jb_ee_2006_engl.pdf

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.

5 Highlights and prospects

After significant growth rates well above the global average the German PV market came to a temporary stagnation in 2006. This effect seems to result from the current shortage of silicon supply as well as from the interdependency between system prices and feed-in tariffs. But for 2007 the market grew again up to 1100 MW new installed systems.: Based on the evaluation of the EEG feed in-tariff for renewable energies will be change, starting in 2009. As a result, the depression rates for PV will be increased from presently 5 % per year to 8 – 10 % per year.

The German PV industry intends to extend their production capacities further. From 2010 on, an increasing share of the turnover will be earned form export activities. In an environment of competition, it is therefore important to offer high quality state of the art products. The current technical and economical status does not allow standstill. Enhancement of production efficiency and at the same time lowered costs stay on the agenda. For that reason, high-level R&D together with sustainable market supporting mechanisms like the EEG are still needed.

Annex A Method and accuracy of data

The accuracy of the assessed data for the installed power is about +/-10%.

Annex B Country information

Electricity prices: 0,19 – 0,26 €/kWh + basic fee for households. As an average 0,19 €/kWh is adequate. For industrial supply, the prices are lower depending on consumption. The production cost of conventional power plants are in the range of 5 – 8 €/kWh. Tendency to increasing prices in 2008.

Typical household consumption: 4000 kWh/yr.

Typical metering and tariff structure: The metering systems are installed in the household. The measurement takes place once a year and a payment in a one or two month period with an invoice at the end of the year.

Average household income: 23.400 €/yr (net, 2006); 34.000 €/yr (gross, 2006) (for a married person, solely working, 2 children; (household income can vary by different private status).

Typical mortgage interest rate: around 5 %/yr

Voltage: 230 V / 380 V

Electricity Structure: There are parallel structure of large enterprises (i.e. E-on, RWE, Vattenfall), city owned companies and industrial producers for their own facilities. The grid belongs mostly to the producers.

Price of diesel fuel: 1,10 – 1,20 €/l.

Typical values for PV system of household: 1- 5 kWp.