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 2008

Version 2

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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Definitions, Symbols and Abbreviations

For the purposes of this and all IEA PVPS 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/m^2, cell junction temperature of 25°C, AM 1,5 solar spectrum – (also see 'Rated power').

Rated 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.

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

Off-grid domestic PV power system: System installed to provide power mainly to a household or village not connected to the (main) utility grid(s). Often a means to store electricity is used (most commonly lead-acid batteries). Also referred to as 'stand-alone PV power system'. Can also provide power to domestic and community users (plus some other applications) via a 'mini-grid', often as a hybrid with another source of power.

Off-grid non-domestic PV power system: System used for a variety of industrial and agricultural 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 to provide power to a grid-connected customer or directly to the electricity grid (specifically where that part of the electricity grid is configured to supply power to a number of customers rather than to provide a bulk transport function). Such systems may be on or integrated into the customer's premises often on the demand side of the electricity meter, on public and commercial buildings, or simply in the built environment on motorway sound barriers etc. They may be specifically designed for support of the utility distribution grid. Size is not a determining feature – while a 1 MW PV system on a rooftop may be large by PV standards, this is not the case for other forms of distributed generation.

Grid-connected centralized PV power system: Power production system performing the function of a centralized power station. The power supplied by such a system is not associated with a particular electricity customer, and the system is not located to specifically perform functions on the electricity grid other than the supply of bulk power. Typically ground mounted and functioning independently of any nearby development.

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 PV 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 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. These may be implemented by government, the finance industry, utilities etc.

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.

Currency: The currency unit used throughout this report is EURO €

PV support measures:

Enhanced feed-in tariff	an explicit monetary reward is provided for producing PV electricity; paid (usually by the electricity utility) at a rate per kWh somewhat higher than the retail electricity rates being paid by the customer
Capital subsidies	direct financial subsidies aimed at tackling the up-front cost barrier, either for specific equipment or total installed PV system cost
Green electricity schemes	allows customers to purchase green electricity based on renewable energy from the electricity utility, usually at a premium price
PV-specific green electricity schemes	allows customers to purchase green electricity based on PV electricity from the electricity utility, usually at a premium price
Renewable portfolio standards (RPS)	a mandated requirement that the electricity utility (often the electricity retailer) source a portion of their electricity supplies from renewable energies (usually characterized by a broad, least-cost approach favouring hydro, wind and biomass)
PV requirement in RPS	a mandated requirement that a portion of the RPS be met by PV electricity supplies (often called a set-aside)

Investment funds for PV	share offerings in private PV investment funds plus other schemes that focus on wealth creation and business success using PV as a vehicle to achieve these ends
Income tax credits	allows some or all expenses associated with PV installation to be deducted from taxable income streams
Net metering	in effect the system owner receives retail value for any excess electricity fed into the grid, as recorded by a bi-directional electricity meter and netted over the billing period
Net billing	the electricity taken from the grid and the electricity fed into the grid are tracked separately, and the electricity fed into the grid is valued at a given price
Commercial bank activities	includes activities such as preferential home mortgage terms for houses including PV systems and preferential green loans for the installation of PV systems
Electricity utility activities	includes 'green power' schemes allowing customers to purchase green electricity, large-scale utility PV plants, various PV ownership and financing options with select customers and PV electricity power purchase models
Sustainable building requirements	includes requirements on new building developments (residential and commercial) and also in some cases on properties for sale, where the PV may be included as one option for reducing the building's energy foot print or may be specifically mandated as an inclusion in the building development

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 21 participating countries are Australia (AUS), Austria (AUT), Canada (CAN), Denmark (DNK), France (FRA), Germany (DEU), Israel (ISR), Italy (ITA), Japan (JPN), Korea (KOR), Malaysia, Mexico (MEX), the Netherlands (NLD), Norway (NOR), Portugal (PRT), Spain (ESP), Sweden (SWE), Switzerland (CHE), Turkey, 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 Tasks (research projects / activity areas) is the responsibility of Operating Agents. Information about the active and completed tasks can be found on the IEA-PVPS website www.iea-pvps.org

Introduction

The objective of Task 1 of the IEA Photovoltaic Power Systems Programme is to facilitate the exchange and dissemination of information on the technical, economic, environmental and social aspects of photovoltaic power systems. An important deliverable of Task 1 is the annual Trends in photovoltaic applications report. In parallel, National Survey Reports are produced annually by each Task 1 participant. This document is the German National Survey Report for the year 2008. Information from this document will be used as input to the annual Trends in photovoltaic applications report.

The PVPS website www.iea-pvps.org also plays an important role in disseminating information arising from the programme, including national information.

1 EXECUTIVE SUMMARY

1.1 Installed PV power

New installed (power) [1]	1.500 MWp
Total installed power [1]	~ 5.300 MWp

1.2 Costs & prices

Turnkey Prices of Typical PV Applications (VAT excluded (19%) , net, prices rounded, prices at end of 2008) [4]

1 – 2 kWp:	4.450 €/kWp (off-grid / grid connected)
2 – 5 kWp:	4.130 0 €/kWp (usually grid connected)
5 - 10 kWp:	3.910 €/kWp (usually grid connected)
10 -50 kWp:	3.650 €/kWp (usually grid connected)

1.3 PV production

Production of cells [1]	1450 MWp
Production of wafers [2,9]	710 MWp
Production of feedstock silicon [2,9]	11.200 t
PV power generation [1]	~4.300 GWh

1.4 Budgets for PV

R&D budget for PV projects by BMU [5]	39,9 Mio. €
R&D budget for PV projects by BMBF [5]	19,5 Mio. €
Industrial R&D investments [1]	190,0 Mio €

2 THE IMPLEMENTATION OF PV SYSTEMS

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. Additionally, the aim is to ensure that all measures are affordable and keep pace with the economic development. With respect to these conditions, the German government adopted 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. Among others, it is expected that 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.

Originally, for the electricity sector a national target for renewable energies of 12,5 % by 2010 and 20 % by 2020 was set. While in 2000 a share of 6,3 % for renewable energies was assessed, for 2008 a share of 15 % was estimated [7] which means exceeding the 2010 target already now. Therefore, the German Parliament agreed to increase the 2020 target to 30 %. Photovoltaic (PV) is part of this development. Meanwhile, a PV capacity of more than 5 GW is installed. Driven by the Renewable Energy Sources Act (EEG), PV shows an impressive development.

Since 2004, Germany is the country with the highest annual PV installation worldwide. This remarkable development is based on the “Renewable Energy Sources Act (EEG)” [8]. The EEG rules the input and favourable payment of electricity from renewable energies by the utilities. In late 2008, an amendment of the EEG was decided. In order to stimulate a stronger price reduction, the degression rate of tariffs for new PV systems was raised from 5 % to 8 % in 2009 and 2010 (for systems smaller 100kW). Moreover, the degression rate will be adapted to the market growth. If the marked deviates form a predefined corridor, the degression rate will be increased or decreased by 1 % for the next year. For 2009 the corridor was set between 1 000 MW and 1 500 MW. The rates are guaranteed for an operation period of 20 years. The bonus for façade integrated systems of 5 Ct/kWh was eliminated.

For small systems (< 30 kW) installed in 2009 there is now the possibility to obtain a reimbursement of 25 Ct/kWh for PV power consumed by the system operator or his neighbourhood. If one includes the savings on electricity delivery costs (approx. 20 Ct/kWh) this way of operating the PV system may become attractive as every kW PV power is worth 45 Ct under these conditions.

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 2007 there is a stable and slow increasing request for stand alone systems. Estimate by BSW

(Bundesverband Solarwirtschaft – the German Solar Industry Federation) [1] indicate that end of 2008 around 40 MW were installed, 4,5 MW more than in 2007.

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 published in April 2008 the new installed capacity of around 1500 MW for grid-connected systems. That means in total about 5,3 GWp installed capacity. [1]

2.2 Total photovoltaic power installed

The EEG accelerated the installation of grid-connected PV-systems in Germany significantly. The capacity installed in recent years is still a topic of discussion. The dilemma is based on the fact that the high number of installations makes it difficult to track each single system. The current data on the development of the German market since 1992 is shown in table 2. For 2008 the BSW published a new capacity of grid connected systems of 1 500 MW resulting in a cumulated capacity of 5,3 GW at the end of the year. With respect to the statistical difficulties, there is hope for improvement. Since the beginning of 2009 the owner of new PV systems are legally obliged to register their systems at the German Federal Network Agency. Only registered systems will receive the favourable feed-in tariff of the EEG.

In addition to the market of grid connected systems, there is a steadily growing request for stand alone systems. First estimates indicate that in 2008 around 5 MW were installed mainly for industrial applications like the automotive sector, traffic signals etc.

Table 1: PV power installed during calendar year 2008 in 2 sub-markets.

Sub-market/ application	off-grid domestic	off-grid non-domestic	grid-connected distributed	grid-connected centralized	Total
PV power installed in 2008 (kW)	5		1.500		

Table 2: 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	2008
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	40
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	5300
Total	5,6	8,9	12,4	17,7	27,8	41,8	53,8	69,4	113,7	194,6	278	431	1034	1926	2759	3835,5	5340

Due to the relatively mature PV market in Germany technical orientated demonstration and large field test activities are not in the centre of interest anymore. The proof that PV works in different kind of applications is done. Therefore, the industry focuses their activities in process optimization to reduce the production cost and to increase the quality of their products. Also recycling is becoming more interesting.

Germany has a wide range of policy and promotional initiatives. First of all is the mentioned EEG with the feed-in tariff. Additionally there are tax credits for investments in PV and loans by KfW for measures to reduce energy consumption and the application of renewable energies in buildings. Some states award grants for PV plants.

A lot of journals offer information about PV, some only specific for PV, others under the theme “Renewables”.

The internet provides several websites, dedicated to PV and renewable energies like:

http://www.bmu.de

http://www.erneuerbare-energien.de/inhalt/3860/

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.german-renewable-energy.com

http://www.renewables-made-in-germany.com/en/photovoltaics/

http://www.renewablesb2b.com

BSW represents the German PV and solar thermal industry and supply a lot of market data (http://www.solarwirtschaft.de). The Germany Trade & Invest [9] has the task to acquire foreign enterprises for investments in Germany. This organisation supplies a lot of commercial information and supports investors individually (http://www.gtai.com).

As the result of these long term initiatives, there is a broad awareness and acceptance for renewable energy and PV by the public. In consequence, a constant demand exists for PV products.

Beside these promotion activities, PV industry is an important branch in the technology sector and gains more and more attention in the public.

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

Until end of 2008, more than 500 large scale photovoltaic plants with more than 200 KWp are in operation in Germany, 120 new large plants were put into service during the year. The installed capacity of these large PV plants amounts to around 700 MWp [14].

The largest PV power plants based on thin film technology installed in 2008 are:

Brandis	40	MWp
Köthen	14,75	MWp
Helmeringen	10	MWp
Eckolstädt	8,5	MWp
Trier	8,4	MWp
Igling-Buchloe	5,8	MWp
Wörrstadt	5,6	MWp

In October 2008 the Fraunhofer-Gesellschaft opened the "Center for Organic Materials and Electronic Devices Dresden" (COMEDD). Its primary purpose is the development of economically viable and production-oriented processes for organic semiconductor devices such as organic light-emitting diodes and organic solar cells.

The Fraunhofer ISE inaugurated its new 600m² laboratory for silicon material research: the Silicon Materials Technology and Evaluation Center (SIMTEC). The focus of the new center is on silicon crystallization and wafer technology as well as crystalline silicon thin film technology.

TÜV Rheinland Group is constructing one of the world's most modern test centers for solar modules at its headquarters in Cologne. Around EUR 4 million will be invested in the new building and in ultramodern technical equipment for monitoring safety, quality and energy efficiency in photovoltaic modules and solar collectors. From summer 2009, over 40 experts will be working in the new test centre, which, with 1,800 m², will be three times as large as the existing one.

2.4 Highlights of R&D

In 2008 the highlights of R&D were as follows:

- Since 2005, Q-Cells is working on high-efficiency silicon solar cells. To boost their own R&D capacities, Q-Cells opened its own research centre in August 2008. This centre will be home of two projects funded by BMU namely QUEBEC and Alba. In both projects, Q-Cells relies on the expertise of the Fraunhofer ISE, Freiburg and the ISFH, Hameln. QUEBEC aims for 20 % efficiency on monocrystalline silicon while Alba addresses high efficiency cells on multicrystalline silicon. It is expected that both cell concepts will be transferred into pilot production in the near future.
- In December 2008, Concentrix Solar opened a 25 MW production facility for concentrating PV Systems (CPV – see figure 1) in Freiburg. Concentrix is a spin-off of the Fraunhofer ISE. The ISE itself published very recently a new world record of 41,1 % for a cell for CPV applications. The realisation of highly efficient CPV system using this type of cell is currently funded by the BMU.
- Since April 2008 a German consortium of Solar World, University of Stuttgart and Zentrum für Sonnenenergie- und Wasserstoff- Forschung (ZSW) participates in the new IEA PVPS Task 12 - PV Environmental Health & Safety Activities.

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

In Germany, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) takes the responsibility for the renewable energies within the Federal Government.

Research and Development (R&D) is conducted under the 5th Programme on Energy Research and Energy Technology "Innovation and New Energy Technologies" [15]. The Programme was originally designed to be valid for the period from 2006 to 2008. It was now extended until 2010. Within this framework, the BMU as well as the

BMBF (Federal Ministry of Education and Research) support R&D on different aspects of PV. Both parts of the programme are administrated by the Project Management Organisation PtJ in Jülich.

Funding Activities of the BMU

In December 2008, the BMU released a new open call for tender [10]. Concerning PV, the call addresses five focal points:

- Silicon wafer technology, especially the production of solar silicon, reduced material consumption and the development of new cell and module concepts for future industrial productions.
- 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 and standardisation of island systems for global applications.
- Concentrated Solar Power and other 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.

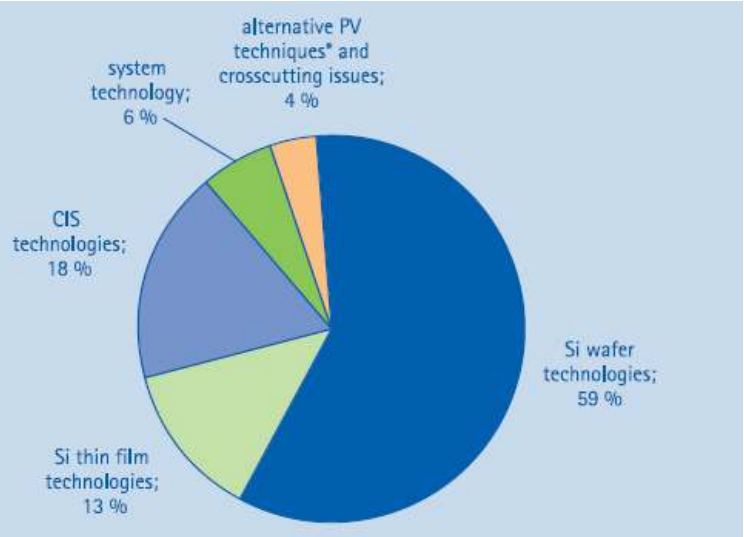

*Fig. 2 - BMU funding of R&D in 2008 (*concentrating PV, CdTe and crosscutting issues).*

In 2008, the BMU support for R&D projects on PV amounted to about 39,9 MEUR shared by 130 projects in total. The distribution of the budget shows that the focal point still is on wafer based silicon technologies (59 % of the budget). The second centre of attention lies on thin-film technologies (32 %). The development of system technology (6 %) and alternative technologies like concentrating PV and crosscutting issues (4 %) are funded as well.

In accordance with the German PV R&D strategy, 38 new grants were contracted in 2008. The

funding for these projects amounts to 39,7 MEUR in total.

Funding Activities of the BMBF

In 2008, the BMBF published its concept paper "Basic Energy Research 2020+" aiming for the support of long-term R&D on renewable energies [11]. Currently there are two focal points of engagement:

- A joint initiative of BMBF and industry addresses the development of organic solar cells.
- Networks aiming for the development of thin-film solar cells were initiated in 2008. They place emphasis on topics such as material sciences including nanotechnology, new experimental or analytical methods and the usage of synergies with other fields of research such as microelectronics or bionics.

In 2008, 8 cooperative R&D projects were granted in total. The funds amount to a total of 19,5 MEUR.

Additionally, the BMBF funds the development of the "Solarvalley Mitteldeutschland" cluster as part of the Federal High-Tech Strategy. In early 2008, a competition to promote outstanding innovation oriented alliances was launched. The "Solarvalley Mitteldeutschland" cluster, which comprises most of Germany's PV industry, was one of the five winners and will now be funded to boost its profile, eliminate impediments to its strategic development and grow into an internationally attractive centre. The BMBF allocated 200 MEUR grants in total for all five winners.

Table 3: Public budgets for R&D, demonstration/field test programmes and market incentives.

Public and industrial budgets for PV R&D

R&D budget for PV projects by BMU [5]	39,9 Mio. €
R&D budget for PV projects by BMBF [5]	19,5 Mio. €
Industrial R&D investments [1]	190,0 Mio €

PV feed-in tariff of the EEG

Year	2003	2004	2005	2006	2007	2008	2009
Tariff* (€ct/kWh)	46.0	57.4	54.5	51.8	49.2	46,75	43,01

National Programmes for market stimulation [12]

Funding organisation	Kind of Funding	Name of Programme
By Government		
Local utilities	Feed-in tariff	EEG
Local fiscal authorities	Tax credits for PV investments by producing enterprises	Investitionszulage
By Bank		
KfW	Loans for private PV investments	Erneuerbare Energien Standard
KfW	Loans for PV investments by communities and their enterprises	Kommunal investieren
KfW	Loans for investment in the infrastructure of communties to save energy and change to renewable energies	KfW- Kommunalkredit
By Federal States		
Bavaria	Grants for PV demonstration projects	Rationellere Energiegewinnung – und Verwendung im Gewerbe
Hamburg	Grants for thin film PV installations on oof tops	Hamburger Klimaschutzprogramm Photovoltaik
Niedersachsen	Mainly loans for small and medium enterprises	Niedersächsisches Innovationsförderprogramm (Gewerbe)
NRW	Grants for buildings with high energy efficiency	Progress.nrw “Rationelle Energieverwendung, Regenerative Energien und Energiesparen
Rheinland-Pfalz	Grants for new buildings with high energy efficiency	Förderprogramm hochenergieeffiziente Neubauten
Saarland	Grants for PV installations on schools and demonstration projects	Zukunftsenergieprogramm Technik

3 INDUSTRY AND GROWTH

The German PV industry still experiences a period of solid growth. 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 growing significantly taking advantage of the global silicon supply shortage of recent years.

Silicon Wafer Technology

With Wacker, one of the world largest suppliers of silicon for the semiconductor and PV industry, Joint Solar Silicon, PV Silicon and Scheuten SolarWorld Solizium now at least four companies are in the silicon feedstock business in Germany. From 2009 on, a production capacity of more than 17 000 t equal to roughly 1 300 MW will be reached.

The total production capacity for wafers now amounts to around 2 000 MW. The main supplier of silicon wafers is still Deutsche Solar AG in Freiberg. Besides this company there are another five to six Germany based wafer manufacturers like PV Silicon at Erfurt or Ersol (formerly ASI) at Arnstadt. Silicon ribbons are produced by Wacker Schott Solar (EFG-ribbon) in Alzenau and Sovello (formerly EverQ - String-ribbon) in Thalheim.

The cell production in Germany shows a steady growth. Currently, twelve companies are engaged. Amongst these, Q-Cells in Thalheim is not only the biggest cell producer in Germany but also worldwide. The production of modules grew again. There are now more than fifteen companies with a production capacity of 1 MW and more listed. Amongst these, the biggest ones are Aleo Solar, Solar Factory, Solarwatt, and Solon, all with a production of 100 MW and more.

Thin-Film Technologies

In addition to the silicon wafer activities, there is an increasing number of companies investing in thin-film production lines. Eleven companies are operating or building production facilities for silicon thin film modules with a total capacity of 500 to 600 MW. CIS technologies are used by twelve companies resulting in a production capacity for 2009 of roughly 300 MW. CdTe modules are currently fabricated by two companies. In total, the production of thin-film modules amounts currently to roughly 290 MW a factor of 3 times more than 2007 and now 1/3 of the silicon wafer module production. From 2009 on, thin-film technologies will have a production capacity of more than 1 000 MW, half of the module production capacity of silicon wafer technologies.

Besides the above described manufacturing of feedstock, wafers, cells and modules, the fabrication of **concentrating PV** (CPV) is entering the scene. In 2009, the production capacity will be around 30 MW.

Another important business in Germany is the **inverter industry**. Besides SMA Solar, the world-leader producing around 1 000 MW alone, there are more than another 10 companies producing state-of-the-art inverters. For 2008 a production of 1 600 MW was reported [2].

3.1 Production of feedstocks, ingots and wafers

Table 4: Production and production capacity information for the year for silicon feedstock, ingot and wafer producers in 2008 [2]

Producers	Process & technology	Total Production	Maximum production capacity	Product destination
Silicon feedstock		*t/year*	*t/year*	
Wacker-Chemie	Silicon feedstock	11.000 t	14.500	market
Joint Solar Silicon GmbH & Co.KG	Silicon feedstock	200	850	subsidiary
PV Crystalox Solar Silicon	sc-Si ingots.	*?*	*900*	market
Wafer		*MW*	*MW/year*	
ASI Industries	sc-Si wafers	40	180	market
Conergy	mc-Si wafers	40	200	subsidiary, market
Deutsche Solar AG (Solarworld)	mc-Si wafers	380	530	subsidiary, market
Sovello AG (ex- EverQ)	mc-Si wafers	80	100	subsidiary
PV Silicon AG	sc-Si wafers	70	70	market
Wacker Schott Solar GmbH	mc-Si wafers	100	120	subsidiary

3.2 Production of photovoltaic cells and modules

Table 5: Production and production capacity information for 2008 for each manufacturer [2]

Cell/ Module manufacturer	Technology	Total Production (MW)		Maximum production capacity (MW/yr)	
		Cell	Module	Cell	Module
1. Aleo AG		0	100	0	180
2. Algatec Solarwerke Brandenburg GmbH		0	15	0	15
3. ASS Automotiv Solar Systems GmbH		0	14	0	14
4. Arise Technologies Deutschland GmbH		13	0	40	0
5. Centrosolar AG	mc-Si	0	76	0	91
6. Conergy	mc-Si	50	60	100	250
7. Deutsche Cell GmbH,	mc-Si	170	0	190	0
8. Ersol Solar Energy GmbH Erfurt	mc-Si	140	0	220	0
9. Sovello AG (ex-EverQ)	string-ribbon, mc-Si	80	80	100	100
10. GSS GmbH and IPEG GmbH,	mc-Si	0	6	0	16
11. Heckert B.X.T. Solar GmbH		0	25	0	60
12. Q-Cells AG, Thalheim	mc-Si	585	0	760	0
13. Scheuten Solar Technology	sc-Si, mc-Si	20	81	35	100
14. Schott Solar GmbH,	EFG, mc-Si	120	0	170	0
15. Schüco international KG		0	5	0	5
16. Solara AG, Hamburg		0	0	0	0
17. Solar-Fabrik AG	sc-Si , sc-Si	0	70	0	130
18. Solar Factory GmbH (Solarworld)		0	140	0	150
19. Solarnova GmbH, Wedel	sc-Si, mc-Si	0	5	0	10
20. Solarwatt Solar-Systeme GmbH,	sc-Si and mc-Si	0	107	0	120
21. Solarwatt Cells GmbH		13	0	16	0
22. SOLON SE	Sc-Si, mc-Si	0	120	0	260
23. Sunways A.G.	'power cells' mc-Si	30	0	76	0
24. Sunplastics GmbH		0	0	0	0
25. Sunware GmbH & Co. KG Solartechnik		0	0	0	1
26. Webast Solar AG		0	10	0	40
27. Wulfmeier Solar GmbH		0	0	0	1
TOTALS		**1221**	**914**	**1707**	**1543**

Thin Film manufacturers	Technology	Total Production (MW)		Maximum production capacity (MW/yr)	
		Cell	Module	Cell	Module
1. Avancis GmbH	CIS	3	3	20	20
2. Global Solar Energy	CIS	1	1	20	20
3. Johanna Solar Technology GmbH	CIS	1	1	30	30
4. Odersun	CIS	1	1	35	35
5. Solibro GmbH	CIS	5	5	30	30
6. Sulfurcell	CIS	2	2	3	3
7. Würth Solar GmbH,	CIS	20	20	30	30
8. Calyxo GmbH (Q-Cells)	Cd-Tl	3	3	25	25
9. First Solar GmbH	Cd-Te	196	196	196	196
10. Centrosolar	a-Si	3	3	3	3
11. Schott Solar AG	a-Si	15	15	35	35
12. Signet Solar GmbH	a-Si	2	2	20	20
13. Sontor GmbH (Q-Cells)	a-Si	4	4	25	25
14. Ersol Solar Energy AG	a-Si/µ-Si	20	20	40	40
15. Inventux	a-Si/µ-Si	2	2	33	33
16. Sunfilm AG	a-Si/µ-Si	5	5	50	50
17. CSG Solar	cristalline Si	6	6	10	10
TOTALS		**289**	**289**	**605**	**605**

Concentrators	Technology	Total Production (MW)		Maximum production capacity (MW/yr)	
		Cell	Module	Cell	Module
1. Archimedes Solar GmbH		0	0	0	0
2. Concentrix		1	0	25	0
3. SolarTec AG		2	0	2	0
TOTALS		**3**	**0**	**27**	**0**

PV Technology Group		Total Production (MW)		Maximum production capacity (MW/yr)	
		Cell	Module	Cell	Module
Cell/ Module		**1221**	**914**	**1707**	**1543**
Thin Film		**289**	**289**	**605**	**605**
Concentrators		**3**	**0**	**27**	**0**
Totals		**1513**	**1203**	**2339**	**2148**

An excellent overview of German PV manufacturers is given by "Germany Trade & Invest" [9]: http://www.gtai.com/uploads/media/FactSheet_PV_Manufacturers_Spring09_GTAI_01.pdf

3.3 Module prices

Table 6: Typical module prices for a number of years [after 3]

Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004.	2005	2006	2007	2008
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	3,0 – 4,3
Best price															4,0	3,0	2,0

3.4 Manufacturers and suppliers of other components

Germany hosts numerous leading manufacturing companies in photovoltaics. It thus features one of the largest markets for PV equipment manufacturers. Significant business opportunities exist at all stages of the PV supply chain.

German PV equipment manufacturers sold machinery worth € 2.3 billion in 2008.

An excellent overview of German PV equipment suppliers is given by "Germany Trade & Invest" [9]: http://www.gtai.com/uploads/media/FactSheet_PV_Equipment_Spring09_GTAI_01.pdf

3.5 System prices

Table 7: **Turnkey Prices of Typical Applications**

Turnkey Prices of Typical PV Applications (VAT excluded (19%) , net, prices rounded, prices at end of 2008) [4]

1 – 2 kWp:	4.450 €/kWp (off-grid / grid connected)
2 – 5 kWp:	4.130 €/kWp (usually grid connected)
5 - 10 kWp:	3.910 €/kWp (usually grid connected)
10 -50 kWp:	3.650 €/kWp (usually grid connected)

Table 7a: National trends in system prices

Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Price €/kW	8 390	7720	7060	6540	6190	6540	6400	5600	5080	5300	5600	5400	5500	4200

3.6 Labour places

The BSW estimates that meanwhile around 10.000 companies with 48.000 employees are active in the PV business. More than 130 companies are producer of cells, modules and components. The turnover in 2008 amounted to 7 billion EUR [1].

Table 8: Estimated PV-related labour places in 2008 [1]

Labour places in total: 48.000

- 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.

3.7 Business value

Provide an estimate of the value of PV business in your country by the Gross Domestic Product approach, using Table 7 and as described in the Swiss discussion paper previously circulated (further copies from Task 1 OA).

Table 9: Value of PV business in Germany [1]

New installed (power)	1.500 MWp
Total installed power	~ 5.300 MWp
Production of cells	1450 MWp
Production of wafers	710 MWp
Production of feedstock silicon	11.200 t
PV power generation	~ 4.300 GWh
Turn-over PV industry	~ 7 bill. €
Export quota	46 %
Investment in production capacity	2.150 Mio. €

The market share of German enterprises in the whole industry value chain for the world market is estimated by around 20 %.

Table 10: PV support measures

	On-going measures	Measures that commenced during 2008
Enhanced feed-in tariffs	Renewable Energy Sources Act (EEG), 43,01 €ct/kwh for PV	
Capital subsidies for equipment or total cost	Yes, in some states	
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	
Income tax credits	None specific for PV, but the regular depreciations by commercial investments	
Net metering	yes	
Net billing	yes	
Commercial bank activities e.g. green mortgages promoting PV	yes	
Electricity utility activities	yes	
Sustainable building requirements	Yes, by law for new buildings, there are provisions for energy efficiency	

3.8 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.

An excellent overview about the institutions engaged in R&D in PV is given by "Germany Trade & Invest" [9]: http://www.gtai.com/uploads/media/FactSheet_PV_R_D_Spring09_GTAI.pdf

Climate Initiative

Since the beginning of 2008 the Federal Environment Ministry (BMU) has had additional funds at its disposal from the sale of emissions allowances for the implementation of a Climate Initiative. In 2008 a total of 400 million euro was available, of which 280 million was invested in Germany and 120 million euro in developing and newly industrialising countries. For 2009 this has been increased to 460 million euro of additional funding for the BMU budget.

The goal of the Climate Initiative is to tap existing potential for reducing emissions in a cost-effective way and to advance innovative model projects for climate protection. Specifically, the BMU promotes climate protection measures for increased energy efficiency and greater use of renewable energies. Furthermore, the International Climate Initiative supports measures for adapting to climate change and for conserving climate-relevant biodiversity in developing and newly industrializing countries. It thus aims to bring new momentum to negotiations on an international climate agreement for the post-2012 period.

The BMU is therefore establishing an innovative and reliable mechanism for international climate protection financing and making an important contribution to reaching ambitious climate protection targets in Germany, Europe and worldwide.

a) National Climate Initiative

The focus of the National Climate Initiative is on consumers, industry and municipalities and on social and cultural establishments. The support programmes and individual projects aim to

- advance climate-friendly technologies in a targeted way
- demonstrate and disseminate innovative climate technologies using model projects and
- identify and overcome barriers preventing the implementation of climate protection measures.

Five support programmes have been published so far as part of the national initiative:

- Guidelines on promoting climate protection projects in municipalities and in social and cultural establishments
- Climate incentive programme for the installation of mini-CHP plants (CHP: combined heat and power) in private households and commercial enterprises
- Climate incentive programme for commercial refrigeration plants
- A programme for promoting projects to optimise biomass energy use and
- An extension of the existing market incentive programme for renewable heat.

The BMU aims to develop a general support framework for the market launch and penetration of climate technologies and to present this to the EU Commission for approval. Further support programmes can then be set up (from 2009) within this framework, including for industry.

As well as support programmes, the BMU is initiating and supporting individual climate protection projects. For example, consumer advice centres will soon launch a nationwide "information campaign on climate" to advise households on options for action in all areas of climate protection. The new service supplements the existing energy saving consultation supported by the Federal Economic Ministry (BMWi). An action programme "Climate in Schools and Educational Establishments" comprises coordinated actions on energy saving, improved energy efficiency, the installation of renewable energies, the provision of teaching materials, the qualification of teaching staff, the implementation of model projects, the organisation of climate days and other projects to raise climate awareness. Additionally, several projects are under preparation that serve to help enterprises structure their production processes in a more climate-friendly and thus more cost-effective way. The Climate Initiative also funds further research in the field of renewable energies. Funds are also available for climate projects in the Environmental Innovation Programme.

The effectiveness of the Climate Initiative's programmes and individual projects (e.g. greenhouse gas reduction, multiplier effect, impacts on jobs) is evaluated by a team of research institutes. The programmes will be continuously adapted and further developed on the basis of this evaluation.

The National Climate Initiative makes a valuable contribution to achieving Germany's climate protection target. The German government has set itself the ambitious goal of a 40 percent reduction in greenhouse gas emissions by 2020 compared with 1990. To this end the German cabinet adopted its "Integrated Energy and Climate Programme (IEKP)" on 5 December 2007.

b) International Climate Initiative

The International Climate Initiative supports climate projects worldwide in developing and newly industrializing countries and in transition countries in Central and Eastern Europe. Through this, the BMU is making an effective contribution to emission reductions and adaptation to climate change. This new form of environmental cooperation complements the Government's existing development cooperation.

When selecting projects, the BMU attaches great importance to the development of innovative and multipliable approaches that impact beyond the individual project itself. Through targeted cooperation with partner countries the Climate Initiative provides important momentum for negotiations on an international climate agreement for the post-2012 period.

The focus of the International Climate Initiative lies in the areas of

- promoting sustainable energy supply
- promoting measures for adaptation to the impacts of climate change and conserving biodiversity with climate relevance.

In the field of sustainable energy supply, projects on a scale of up to 60 million euro are to be implemented in 2008. The goal is to support partner countries in establishing an energy supply structure that prevents climate-damaging greenhouse gas emissions where possible. Support is also given towards increasing energy efficiency, expanding renewable energies, reducing environmentally harmful hydrofluorocarbons and for investment-related measures and know-how in the partner country.

In the field of adaptation to climate change, too, projects on a scale of up to 60 million euro are to be implemented in 2008. One particular focus is on the interface between biodiversity conservation and climate, for example the conservation of large forests, which is also very important for the climate.

The funds from the International Climate Initiative will primarily flow into bilateral projects. Additionally, involvement in international climate funds in the context of the Framework Convention on Climate Change and the Kyoto Protocol is also planned.

Due to the strong growth in the photovoltaic sector in 2008 the electricity generation rose to 4.0 bn kWh (2007: 3.1 bn kWh). Solar power thus contributed 0.6 % to total gross electricity consumption. The use of PV avoided 2.7 mio. t of CO2.

3.9 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.

4 FRAMEWORK FOR DEPLOYMENT (NON-TECHNICAL FACTORS)

In 2008, the German PV market again showed an impressive growth. The driving force for this development is the EEG, which was amended in late 2008. Higher degression rates were introduced in order to stimulate additional price reductions. Moreover, through the use of renewable energies such as PV a lower consumption of coal and gas in the electricity sector and thus a reduction of Germany's dependence on energy imports will be accomplished. Therefore, it is expected that the German PV marked will stay at a high level.

The German PV industry intends to extend their production capacities further. 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 for a standstill. Enhancement of production efficiency and at the same time lowered costs stay on the agenda. For this reason, high-level R&D together with sustainable market supporting mechanisms such as the EEG is still needed.

ANNEX A: COUNTRY INFORMATION

1) Electricity prices: 0,19 – 0,26 €/kWh + basic fee for households. As an average 0,22 €/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 €ct/KWh. Tendency to increasing prices in 2008. Strong influence by price level of oil and gas.
2) Typical household consumption: 4000 kW/yr.
3) 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 invoiced at the end of the year.
4) Average household income: 37.500 €/yr (gross, 2008) (for a married person, solely working, 2 children; (household income can vary by different private status).
5) Typical mortgage interest rate: around 5 %/yr
6) Voltage: 230 V / 380 V
7) 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.
8) Price of diesel fuel: 1,10 – 1,30 €/l.
9) Typical values for PV system of household: 1- 5 kWp.

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