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 2009

Prepared on behalf of

BMU – German Federal Ministry for the

Environment, Nature Conservation and Nuclear Safety

August 2010

by

Dr. Lothar Wissing

Forschungszentrum Jülich

Projektträger Jülich,

52425 Jülich

TABLE OF CONTENTS

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^{o}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 (MYS), Mexico (MEX), the Netherlands (NLD), Norway (NOR), Portugal (PRT), Spain (ESP), Sweden (SWE), Switzerland (CHE), Turkey (TUR), the United Kingdom (GBR) and the United States of America (USA). The European Commission, the European Photovoltaic Industry Association and the US Solar Electric Power 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 Germany National Survey Report for the year 2009. 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]	~ 3.845 MWp
Total installed power [1]	~ 9.845 MWp

1.2 Costs & prices

Turnkey Prices of Typical PV Applications (VAT excluded (19%) , net, prices rounded, prices at end of 2009, usually grid connected)[3,4]

1 – 2 kWp:	4.333 €/kWp
2 – 5 kWp:	3.380 €/kWp
5 - 10 kWp:	3.184 €/kWp
10 - 50 kWp:	2.962 €/kWp
30 -100 kWp	2.729 €/kWp
> 100 kWp	2.500 €/kWp

1.3 PV production

Production of cells (Si + thin film) [2,3]	2.456 MWp
Production of ingots and wafers [2,3]	1147 MWp
Production of feedstock silicon [2,3]	18.400 t
PV power generation [8]	~6.200 GWh

1.4 Budgets for PV in 2009

R&D budget for PV projects by BMU [5]	32,9 Mio. €
R&D budget for PV projects by BMBF [5]	~ 20,0 Mio. €
Industrial R&D investments (2008) [1]	163,0 Mio €

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 installation and control components for modules, inverters and batteries.

For the purposes of this report, PV installations are included in the 2009 statistics if the PV modules were installed between 1 January and 31 December 2009, although commissioning may have taken place at a later date.

2.1 Applications for Photovoltaics

Renewable energies are one of the most prominent topics on the political agenda in Germany. The new Federal Government, which was elected in September 2009 laid down in its coalition agreement that the way into a renewable era will be followed consequently. And the efforts of recent years already bear fruits. For 2009, renewable energies had a share of 16.1 % of the domestic electricity production. When compared with the initial targets of 12.5 % for 2010 and 20% for 2020 (meanwhile extended to 30%) one observes that the first steps into this new era are already made. Photovoltaic (PV) is part of this development. At present, a PV capacity of roughly 9.8 GW is installed meaning an increase of around 3.8 GW in 2009 alone.

The main driving force for the PV market in Germany is the Renewable Energy Sources Act (EEG). In terms of achieving expansion targets for renewable energies in the electricity sector, the EEG is the most effective funding instrument at the German government's disposal. It determines the procedure of grid access for renewable energies and guarantees favourable feed-in tariffs for them. In the second half of 2009, the installation of PV systems in Germany was boosted driven by the EEG on the one hand and a decrease of system prices of roughly 30% compared to 2008 on the other hand.

In late 2008, it was decided to raise the yearly degression rate of the EEG solar tariff in order to stimulate a stronger price reduction. For example for rooftop-systems smaller 100 kW the rate changed from 5% to 8%. The resulting tariffs for 2009 were 31.94 ¢/kWh for ground mounted systems, 43.01 / 40.91 / 39.58 / 33.00 ¢/kWh for rooftop systems smaller 30 kW /100 kW / 1 MW / bigger than 1 MW. Moreover, a mechanism was introduced to adapt the degression rate to the market growth. If the marked deviates from a predefined corridor, the degression rate is increased or decreased accordingly by 1% for the following year. For 2009 the corridor was set between 1 000 MW and 1 500 MW. Finally, from 2009 on there is the possibility to get a reimbursement for self consumption if the system size is below 30 kW.

On the background of significantly decreasing system prices, after a first decrease of the EEG tariffs at the beginning of 2010 an additional two-step reduction during 2010 was decided.

In addition to the EEG, PV receives support from other sources: local fiscal authorities provide tax credits for PV investments; the state owned bank KfW-Bankengruppe provides loans for individuals as well as for local authorities.

The picture of the installed PV capacity is now becoming clearer. Since the beginning of 2009 the owner of new PV systems are legally obliged to register their systems at the German Federal Network Agency. For 2009, around 159 850 new systems with a total capacity of 3 806 MW were registered. In addition to the market of grid connected systems, there is a steady request for stand-alone systems. Rough estimates indicate that in 2009 around 5 MW were installed mainly for industrial applications as the automotive sector, traffic signals etc..

Over the last years, not only the German PV market but also the German PV industry showed a strong and steady growth. In 2009, burdens resulting from the world economic crises and increased competition resulted in a far more complex situation. Nevertheless, the German foreign trade and inward investment agency “Germany Trade & Invest” lists in total 70 companies involved in PV production creating a turnover of 8.6 billion EUR in 2009. In addition 62 PV equipment manufacturers supply tools for every step of the PV value chain; they generated an additional turnover of 2.0 billion EUR. Beside this, the development of inverter industry is another success story. At the end of 2009, around 63 000 workers were employed in the PV industry, in handcraft and trade companies.

Research and Development (R&D) is conducted under the 5th Federal Programme on Energy Research and Energy Technology “Innovation and New Energy Technologies”. Within this framework, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) as well as the Federal Ministry of Education and Research (BMBF) support R&D ranging from basic research to applied research on almost all aspects of PV.

2.2 Total photovoltaic power installed

Since the beginning of 2009 the owner of new PV systems are legally obliged to register their systems at the German Federal Network Agency. For 2009, around 159 850 new systems with a total capacity of 3 806 MW were registered. In addition to the market of grid connected systems, there is a steady request for stand-alone systems. Rough estimates indicate that in 2009 around 5 MW were installed mainly for industrial applications as the automotive sector, traffic signals etc..

The figure for total installed capacity corresponds to the data of BSW published in August 2010 with around 3800 MW. Therefore, the accuracy of the data should be better than 10 %.

There are nearly no information about off-grid non domestic and grid connected centralized systems in Germany because the electricity supply is completely connected to the public grid. Therefore, there is no need for these systems and regarding the total installed capacity of PV these systems are negligible.

Table 1: PV power installed during calendar year 2009 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 2009 (kW)	5	-	3840	-	3845

A summary of the cumulative installed PV Power, from 2000-2009, broken down into four sub-markets is shown in Table 2.

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

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Off-grid	13,7	16,6	20	23	26	29	32	35,5	40	45
Grid-connected	100,0	178,0	258	408	1008	1897	2727	3800	5300	9800
Total	113,7	194,6	278	431	1034	1926	2759	3835,5	5340	9845

Remark: There is an inconsistency between the years 2008 and 2009 comparing cumulative installed and additionally installed capacity. In the past, mainly the figures of BSW were used for the table published early in the year. During the year, corrections were made completing the gaps. These corrections are not integrated in former editions of the trend reports.

Another more official source of figures are the charts of the AGEE-Stat (Working Group on Renewable Energies-Statistics) working on behalf of the Federal Ministry of Environment. These charts are being published regularly in March of a year and are provisional, but for the years before they should represent the actual figures (see table 2a).

Table 3a: Installed capacity for electricity generation from PV in Germany adopted from [8]

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total	76	186	296	439	1.074	1.980	2.812	3.977	5.877	8.877

It is obvious that the estimated installations are to low with only 3.000 MW made in March 2010.

It can be expected that by the implementation of the German Federal Network Agency in 2009 the figures will become more reliable and consistent in next year.

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

In 2009, the installed capacity of large PV power plants with more than 200 kWp was 1,314 MW in Germany. 573 MWp capacity was installed over the course of the year [10].

Three large solar installations went into operation in 2009:

54 MW Solarpark Strasskirchen

53 MW Solarpark Lieberose

42 MW Solarpark Finsterwalde.

Due to the 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.

A lot of activities in Institutes and Industry exist in order to improve PV technology.

- Last year, the institutes that constitute the Renewable Energy Research Association (FVEE) once more produced technological advances in important areas: whereas standard silicon solar cells currently achieve efficiency levels up to 16 %, Fraunhofer ISE's Photovoltaic Technology Evaluation Center (PV-TEC) has already achieved almost 17 % under realistic industrial conditions. Levels exceeding 23 % have proved possible in laboratory conditions. With a view to practical applications, the Institute for Solar Energy Research Hameln/ Emmerthal (ISFH) has developed a type of cell that can achieve efficiency levels of 21.8 % on commercially available silicon. In conjunction with the industry, both institutes are working on launching these new cell technologies with a view to establishing efficiency levels of around 20 % in series production in the medium-term.
- In the field of thin-film technologies, the Zentrum für Sonnenenergie- und Wasserstoff-Forschung Baden-Württemberg (ZSW) in Stuttgart recently achieved a new efficiency record of 19.6 % on a preindustrial pilot line for solar cells with a copper-indium-gallium-(di)selenide semiconductor (CIS or CIGS). The standard in this field is currently still between 11 and 13 %. Here too, a transfer to industrial production is envisaged.
- In recent years, several production facilities for amorphous thin-film silicon were also commissioned in Germany. Standard modules in this field achieve 7.5 % efficiency. The more recent tandem technology – based on layered cells of amorphous and microcrystalline silicon (a-Si and µc-Si) – is already in production and achieving 8.5 %. The Forschungszentrum Jülich works with German module and systems manufacturers on concepts for driving down production costs and at the same time improving module efficiency levels. Cells with over 11 % efficiency have already been developed in its laboratories.

2.4 Highlights of R&D

Due to the high support of R&D activities by the BMU and other ministries and the engagement by the industry more than 100 R&D projects are currently running. Consequently, to mention every success of these projects would be too extensive for this report. A good overview is given by the www.forschungsjahrbuch.de, which listed all funded PV projects by BMU in Germany with a description included (in German). Another source is the "2009 Annual Report on Research Funding in the Renewable Energy Sector" published by BMU [5].

But three highlights are remarkable:

- The Zentrum für Sonnenenergie- und Wasserstoff-Forschung Baden-Württemberg (ZSW) has set a new efficiency record for thin-film solar cells. Its CIS or CIGS solar cells with a semiconductor made of copper indium gallium (di)selenide have achieved an efficiency of 19.6 %. The production standard is still 11 to 13 %. The secret of their success lies in a more efficient coating technique, in which the solar cells are deposited in a multi-stage continuous process on automated machinery. This process was previously only possible in the laboratory. Now scientists at ZSW have transferred it to a pre-industrial pilot line. The new record illustrates clearly how excellent laboratory results can also be transferred to production conditions. ZSW is continuing to work on this.
- The Photovoltaic Technology Evaluation Center (PVTEC) at the Fraunhofer Institute for Solar Energy Systems (ISE) in Freiburg has evolved with great success. PV-TEC was established between 2005 and 2007 as part of a project funded by BMU. The aim was to provide a research and development platform for the German photovoltaics industry that would replicate production conditions as closely as possible. The idea was also that Fraunhofer ISE would use PV-TEC to carry out innovative research. These two functions work very well together. PV-TEC now has about 100 employees. In 2008, it attracted around 2.5 million Euros of industry funding, which significantly exceeds expectations. One of the successful processes developed at PV-TEC is based on a solar cell architecture in which both contacts that collect electricity are on the back of the solar cell. Researchers at Fraunhofer ISE have already achieved efficiency levels of almost 17 % on large-area multicrystalline silicon wafers on the PV-TEC research line. This process is currently being transferred to the production line of a German solar cell manufacturer and adapted to their particular material specifications.
- At the 24th European Photovoltaics Conference (EUPVSEC), the EU Commission awarded the Becquerel Prize to Dr. Andreas Bett. He is head of the Materials – Solar Cells and Technology department and is at the same time one of two deputy institute direc tors of the Fraunhofer ISE. The prize, which is a prestigious solar award, is named after French scientist Alexandre Edmond Becquerel, who discovered the photovoltaic effect in 1839. In its nomination, the prize committee emphasized Dr. Bett's services to photovoltaic concentrator technology. In January 2009, Bett's team set a world record in achieving an efficiency level of 41.1 % with a multiple-junction solar cell made of III-V GaInP/GaInAs/Ge semiconductors (gallium indium phosphide/gallium indium arsenide/germanium). The US company Spectrolab, a Boeing subsidiary, has now raised that record to 41.6 %. The jury also highlighted the successful development of the FLATCON® principle by Concentrix Solar GmbH, a company which Bett co-founded.

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” [11]. 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

Every two years BMU invites renowned experts to a photovoltaics strategy meeting in Glottertal to discuss research priorities and draw up guidelines. The 11th Glottertal Strategy Meeting was held in November 2009. As a result of the discussions, the following areas of research currently funded will in future have a greater structural focus:

- silicon wafer technology,
- thin-film technologies,
- systems engineering and grid integration, and
- concentrating photovoltaics.

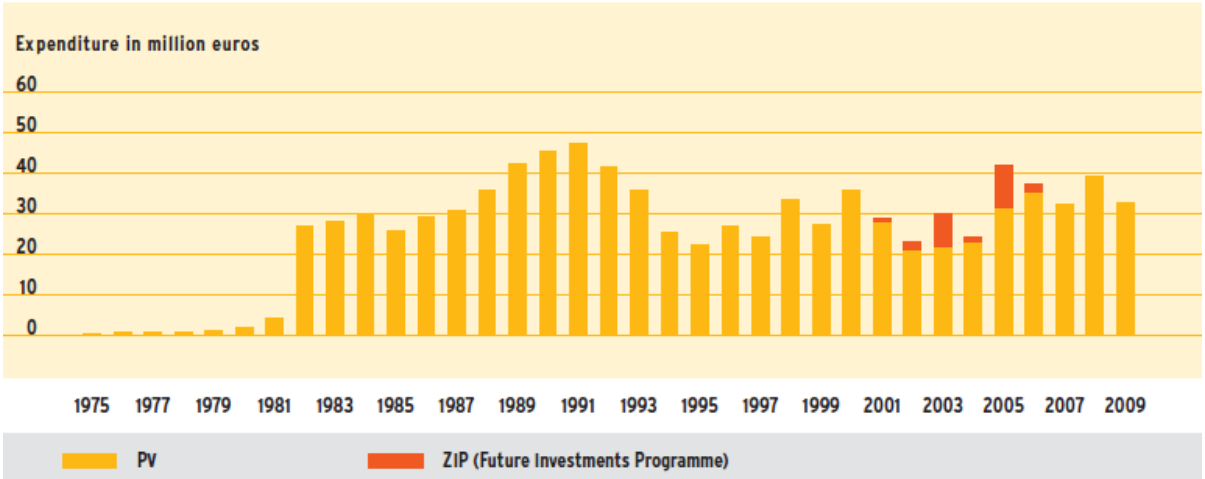
The structural focus will mean that:

- BMU funding will still primarily target precompetitive research and virtually all German companies will be able to access the findings.
- Consequently, the aim is to achieve an allocation of funds, which, as in the past, places greater emphasis on medium- and long-term research. The time horizon for implementing the findings of the research funded is usually five years.

Criteria for selecting projects are:

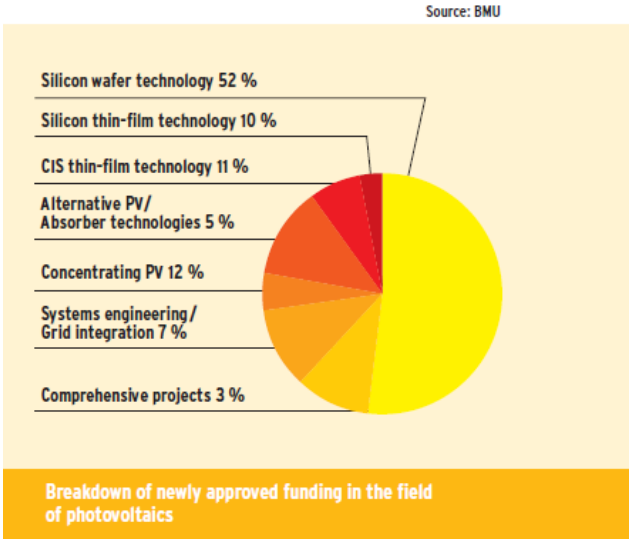
- industry participation and a networking structure; preference is given to collaborative projects;
- development risk and time horizon for implementation;
- possibility of broad dissemination of the research findings, while taking into account the need to protect the findings through patents.

Source: BMU



Photovoltaics: annual project funding between 1975 and 2009

As well as technology-specific topics, cross-cutting issues such as increasing the lifetime of plant and equipment, reducing the energy used in the production process, and recycling are also funded.



In 2009, BMU approved 36 new projects on photovoltaics (2008: 38), corresponding to a funding volume of 31.4 million Euros (2008: 39.7 million Euros). At the same time 32.9 million Euros were allocated to ongoing projects [5].

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 which is complementary to the BMU funding. Concerning PV, currently there are three focal points of engagement:

- A joint initiative of BMBF and industry addresses the development of organic solar cells. Currently there are 13 projects running with a total amount of public funding of 55 MEUR.
- Networks aiming for the development of thin-film solar cells were initiated in 2008. They put emphasis 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 2009, 8 co-ordinated research projects were started receiving a total amount of 20 MEUR in funding.
- Additionally, the BMBF funds the development of the cluster “Solarvalley Mitteldeutschland” as part of the Federal High-Tech Strategy. This cluster comprises most of Germany's PV industry and received grants of 40 MEUR for the next four years.

Table 4: Public budgets for R&D, demonstration/field test programmes and market incentives in Germany 2009.

R&D budget for PV projects by BMU [5]	32,9 Mio. €
R&D budget for PV projects by BMBF [5]	> 20,0 Mio. €
Industrial R&D investments (2008) [1]	163,0 Mio. €

PV feed-in tariff of the EEG until 2009

Year	2003	2004	2005	2006	2007	2008	2009
Tariff* (€ct/kWh) < 30 MWp	46.0	57.4	54.5	51.8	49.2	46,75	43,01

PV feed-in tariff of the EEG in 2010 /2011

	< 30 kWp	up to 100 kWp	up to 1 MWp	> 1MWp
01.01.2010 - 30.06.2010	39,14	37,23	35,23	29,37
01.07.2010 - 31.09.2010	34,05	32,39	30,65	25,55
01.10.2010 - 31.12.2010	33,03	31,42	29,73	24,79
2011	30,06	28,59	26,75	23,26

No feed-in tariff anymore for ground mounted systems on agricultural used fields from 1st of July 2010!

3 INDUSTRY AND GROWTH

3.1 Production of feedstock, ingots and wafers

Table 5: Production and production capacity information for the year for silicon feedstock, ingot and wafer producers in 2009, Germany [2,3]

Producers	Process & technology	Total Production	Maximum production capacity	Product destination
Silicon feedstock		*t/year*	*t/year*	
Wacker-Chemie	Silicon feedstock	18.000 t	21.000	market
Joint Solar Silicon GmbH & Co.KG	Silicon feedstock	400	850	subsidiary
Total		**18.400**	**21.850**	
Wafer & Ingots		*MW*	*MW/year*	
PV Crystalox Silicon GmbH	sc-Si ingots.	17	*150*	market
Bosch Solar Wafers	sc-Si wafers	160	230	market
Conergy	mc-Si wafers	60	200	subsidiary, market
Deutsche Solar AG (Solarworld)	mc-Si wafers	500	500	subsidiary, market
Sovello AG (ex- EverQ)	mc-Si wafers	70	110	subsidiary
PV Silicon AG	sc-Si wafers	100	100	market
Schott Solar Wafer GmbH	mc-Si wafers	240	250	subsidiary
Total		**1347**	**1540**	

3.2 Production of photovoltaic cells and modules

Table 6: Production and production capacity information for 2009 for each manufacturer, Germany [1,2,3]

Cell/ Module manufacturer	Technology	Total Production (MW)		Maximum production capacity (MW/yr)	
		Cell	Module	Cell	Module
1. Alfasolar GmbH			4		20
2. Algatec Solarwerke Brandenburg GmbH			24		63
3. Aleo AG			120		180
4. Asola			23		45
5. Arise Technologies Deutschland GmbH		15,8		85	
6. Bosch Solar Modules GmbH			0		50
7. Centrosolar AG	mc-Si	5	65	5	110
8. Conergy	mc-Si	100	110	250	250
9. Deutsche Cell GmbH,	mc-Si	200		200	
10. Bosch Solar Energy AG	mc-Si	200		270	
11. Sovello AG	string-ribbon, mc-Si	65	60	105	100
12. GSS GmbH and IPEG GmbH,	mc-Si		8		16
13. Heckert B.X.T. Solar GmbH			45		90
14. Q-Cells AG, Thalheim	mc-Si	551		500	
15. Scheuten Solar Technology	sc-Si, mc-Si		82		100
16. Schott Solar GmbH,	mc-Si	218		355	
17. Schüco international KG			5		5
18. Solar-Fabrik AG	sc-Si , sc-Si		60		130
19. Solar Factory GmbH (Solarworld)			150		150
20. Solarnova GmbH, Wedel	sc-Si, mc-Si		7,5		10
21. Solarwatt AG	sc-Si and mc-Si		125		150
22. Solarzentrum Allgäu	mc-Si		0,5		2
23. SOLON SE	Sc-Si, mc-Si		100		260
24. Sunways A.G.	'power cells' mc-Si	60		116	
25. Sunplastics GmbH			0,5		2
26. Sunware GmbH & Co. KG Solartechnik			1		1
27. Webasto Solar AG			20		40
28. Wulfmeier Solar GmbH			0,2		1
29. other		350,2	1054,3		290
Total		**1765**	**2065**	**1886**	**2065**

Thin Film manufacturers	Technology	Total Production (MW)		Maximum production capacity (MW/yr)	
		Cell	Module	Cell	Module
1. Avancis GmbH	CIS	20		20	
2. Global Solar Energy Deutschland GmbH	CIS	10		35	
3. Johanna Solar Technology GmbH	CIS	5		30	
4. Nanosolar Inc.	CIS	4		640	
5. Odersun	CIS	1		35	
6. Solarion GmbH	CIS	0,1		0,2	
7. Solibro GmbH	CIS	14		30	
8. Sulfurcell Solartechnik GmbH	CIS	2		3	
9. Würth Solar GmbH,	CIS	30		30	
10. Calyxo GmbH (Q-Cells)	Cd-Tl	1		10	
11. First Solar GmbH	Cd-Tl	192,5		214	
12. Bosch Solar Thin Film GmbH	a-Si	30		40	
13. Centrosolar	a-Si	5		5	
14. EPV Solar Germany	a-Si	30		30	
15. Inventux Technology AG	a-Si/µ-Si	15		33	
16. Malibu GmbH & Co. KG	a-Si	20		40	
17. Masdar PV GmbH	a-Si	3		30	
18. Schott Solar GmbH	a-Si	22		35	
19. Signet Solar GmbH	a-Si	13		20	
20. Sunfilm AG	a-Si/µ-Si	60		85	
21. other		173,4			
Total		**651**		**1365,2**	

Concentrators	Technology	Total Production (MW)		Maximum production capacity (MW/yr)	
		Cell	Module	Cell	Module
1. Concentrix		10		25	
2. Azur Solar Space Power GmbH		30		100	
Total		**40**	**0**	**125**	**0**

PV Technology Grou		Total Production (MW)		Maximum production capacity (MW/yr)	
		Cell	Module	Cell	Module
Cell/ Module		**1765**	**2065**	**1886**	**2065**
Thin Film		**651**		**1365,2**	
Concentrators		**40**		**125**	
Total		**2456**	**2065**	**3376,2**	**2065**

Another source, BSW published in August 2010 a solar cell production (thin film cells included) of 2.456 MW and a module production of 2.065 MW for 2009. Due to the later date of publishing and the high installation number in Germany, these numbers seem to be more reliable. In the tables above the difference between Photon's and BSW numbers was added under "others". The maximum production capacity of modules was set equal to the total production capacity, because no other figures were available. The real or maximum production capacity should be higher but no reasonable estimate is possible.

Germany is the most developed market in the world for PV with a bundle of enterprises, which are able so supply every device needed for a PV system. Largest companies are Q-Cells, Solarworld AG, Bosch Solar, Bosch Solar and SMA.

Due to the rapid growth of these companies, it is difficult to follow their activities and to be up to date.

A good overview about PV companies given at the website of "Germany Trade and Invest"(GTAI), actualized quarterly:

http://www.gtai.com/homepage/industries/renewable-energies-resources/pv-industry/

In June 2010, GTAI listed 69 PV producer of Silicon, ingots, cells and modules. More than 70 PV Equipment Manufacturers and 57 producers of PV Mounting and Tracking Systems are mentioned. Germany has around 60 enterprises producing inverters, cable, connectors and junction boxes. Most of the large PV companies have at least subsidiaries in foreign countries or even production units. Special designed PV products are available on request.

For detailed information of companies' activities one should look at their websites.

3.3 Module prices

The installation of PV systems in Germany was boosted in the second half of 2009 driven by the Renewable Energy Sources Act (EEG) on the one hand, and on the other hand there was a decrease of system prices and modules of roughly 30 % compared to 2008. In 2010 the feed-in tariff will be reduced again. It can be expected that the module prices will decrease furthermore additionally driven by the strong price competition of Chinese module producers and the US company First Solar.

Table 7: Typical module prices for a number of years

Year	1992	2000	2001	2002	2003	2004.	2005	2006	2007	2008	2009
Module price(s): Typical	5,98	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	1,5 -2,5
Best price								4,0	3,0	2,0	1,0

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 more than € 2 billion in 2009 [1]. As above mentioned an excellent overview of German PV equipment suppliers is given by “Germany Trade & Invest” [9]:

3.5 System prices

Table 8: **Turnkey Prices of Typical Applications**

Turnkey Prices of Typical PV Applications (VAT excluded (19%), net, prices rounded, prices at end of 2009, usually grid connected) [3,4]

1 – 2 kWp:	4.333 €/kWp
2 – 5 kWp:	3.380 €/kWp
5 - 10 kWp:	3.184 €/kWp
10 - 50 kWp:	2.962 €/kWp
30 -100 kWp	2.729 €/kWp
> 100 kWp	2.500 €/kWp

Table 8a: National trends in system prices (< 10MWp)

Year	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Price €/kW	8 390	6540	6400	5600	5080	5300	5600	5400	5500	4200	3200

The prices are related to roof-top installations and usually the systems are grid-connected in Germany. Less than 10 % of installations are in other categories with specific prices.

The general price trend is downwards. At mid of 2010 the average price for a roof-top system between 5 and 100 kWp is less than 3.000 €/kWp.

3.6 Labour places

The BSW estimates that meanwhile around 10.000 companies with 63.000 employees are active in the PV business. More than 200 companies are producer of cells, modules and components. The turnover in 2008 amounted to 9 billion EUR [1].

Table 9: Estimated PV-related labour places in 2009 [1]

Labour places in total: 63.000

- Installers: 41 %
- Wholesale: 8 %
- Industry: 51 %

Figures for employees in institutes are not available.

3.7 Business value

Table 10: Value of PV business in Germany

New installed (power)	3.845 MWp
Total installed power	~ 9.845 MWp
Production of cells	2.456 MWp
Production of wafers	2.065 MWp
Production of feedstock silicon	18.400 t
PV power generation	6.578 GWh
Industry turnover 2009	~ 9 bill. €
Supplier turnover 2009	~ 2 bill. €
Export quota industry	47 %
Export quota supplier	79 %
Investment in production capacity	1,8 bill. €

4 FRAMEWORK FOR DEPLOYMENT (NON-TECHNICAL FACTORS)

Table 11: PV support measures

	On-going measures	Measures that commenced during 2009
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	

4.1 Indirect policy issues

In 2009 again, the German PV market showed an impressive growth. 3,8 GW were added to the grid. The driving force for this development is the EEG. The EEG rules the input and favourable payment of electricity from renewable energies by the utilities. For PV, the feed-in tariff depends on the system size and whether the system is ground-mounted or attached to a building. Since 2009, there is also a tariff for self consumed power. The rates are guaranteed for an operation period of 20 years. [7] In late 2008, it was decided to raise the yearly degression rate of the tariff in order to stimulate a stronger price reduction. For roof-top-systems smaller than 100 kWp the rate changed from 5 % to 8 %. Moreover, a mechanism was introduced to adapt the degression rate to the market growth. If the marked deviates from a predefined corridor, the degression rate is increased or decreased accordingly by 1 % for the following year. For 2009 the corridor was set between 1 000 MW and 1 500 MW. As the upper boundary of 1 500 MW was exceeded significantly, for 2010 the preliminary degression rate is 9 % instead of 8 %. On the background of significantly lowered system prices, an additional reduction of the feed-in-rates in 2010 was adopted by the parliament. The effect of the market size on the degression rate will be also adapted.

In addition, a decrease of system prices of roughly 30 % in the last twelve month made PV systems economically attractive. The EEG will continue being the basis for a robust growth in the German PV market and PV industry. In parallel, the German PV industry is confronted with an environment of competition. It is therefore important for them 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 are even more important than a few years ago. For that reason, high-level R&D together with sustainable market supporting mechanisms like the EEG are still needed.

4.2 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

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: 0,20 – 0,26 €/kWh + basic fee for households. As an average 0,23 €/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 2009. 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 3,5 %/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.

REFERENCES

[1] BSW (Bundesverband Solarwirtschaft) Statistikpapier "Photovoltaik" (aktualisierte Fassung 08/10), http://www.solarwirtschaft.de/fileadmin/content_files/Faktenblatt_PV_BSW_August.pdf

[2] Photon, January 2010

[3] Photon, April 2010

[4] Photon, May 2010

[5] Innovation through Research, 2009 Annual Report on Research Funding in the Renewable Energies Sector, BMU February 2010/ http://www.bmu.de/files/pdfs/allgemein/application/pdf/broschuere_jahresbericht_forschung_ee_2009_en_bf.pdf

[6] “Bekanntmachung über die Förderung von Forschung und Entwicklung im Bereich erneuerbare Energien“, http://www.erneuerbare-energien.de/files/pdfs/allgemein/application/pdf/bekanntmachung_foerderung_ee.pdf

[7] Renewable Energy Sources Act (EEG), http://www.erneuerbare-energien.de/inhalt/42934/40508/

[8] Development of Renewable Energy in Germany in 2009“, Data of the Federal Environment Ministry on the development of renewable energies in Germany in 2008 (provisional figures) based on information of the Working Group on Renewable Energy Statistics (AGEE-Stat), March 2010, http://www.erneuerbare-energien.de/files/pdfs/allgemein/application/pdf/ee_hintergrund_2009_en_bf.pdf

[9] Germany Trade and Invest, several factsheets http://www.gtai.com/homepage/industries/renewable-energies-resources/pv-industry/

[10] PV Power Plants 2010 Industry Guide, RENI – Renewables Insight by Solarpraxis AG and Sunbeam GmbH. http://www.pv-power-plants.com/fileadmin/user_upload/PVPP_2010_web.pdf

[11] The 5th Energy Research Programme of the Federal Government; Berlin, July 2005, http://www.bmwi.de/English/Navigation/Service/publications,did=74976.html