Germany: The Photovoltaic Industry

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Summary

Germany is the world's largest photovoltaic market. In fact, Germany coverts more solar energy into electricity than any other country. Germany is Europe's leading PV manufacturer and the third largest PV producer worldwide concerning production capacity and number of employees. Double-digit growth is expected to continue in the coming years. Germany also offers easy access to all other rapidly growing European markets, such as Spain, Italy, Greece, and France. National and international companies are taking advantage of the opportunities. The market's main driver is the Renewable Energy Sources Act (EEG), which guarantees PV installation owners fixed feed-in tariffs for 20 years. Within the mix of renewable energies, photovoltaic electric energy generation still remains a relatively small segment in the total renewable energy mix.

The U.S. Commercial Service in Germany strongly recommends American exporters consider participating in the annual "Intersolar" trade fair in Munich. This show, taking place in June, is an excellent vehicle to reach the PV community in Germany and neighboring countries. The U.S. Commercial Service will promote and assist U.S. manufacturers prior, during, and after the fair.

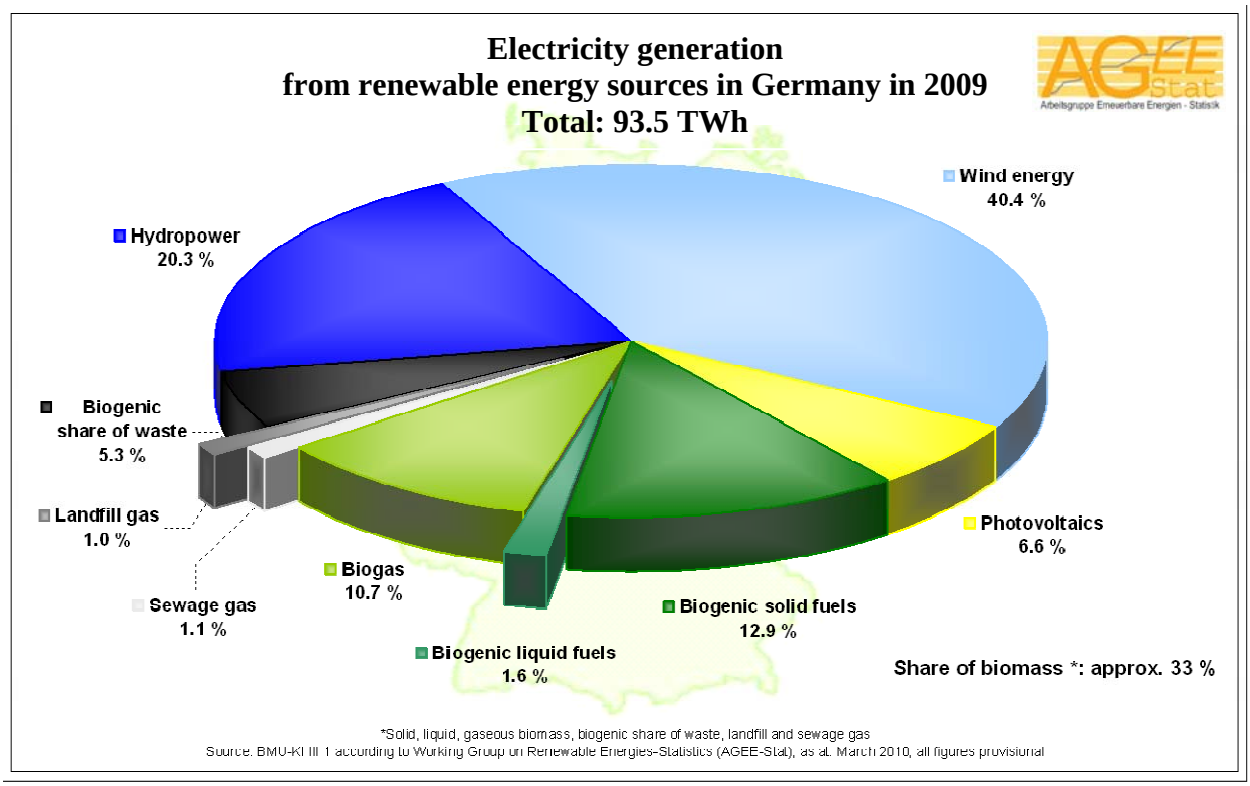
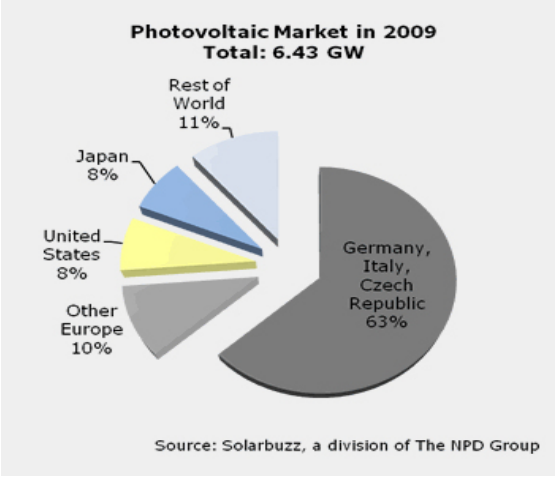


Figure 1: Structure of electricity generation from renewable energy sources in Germany 2009
(BMU: Development of Renewable Energy Sources in 2009)

Within electricity generation from renewable sources the share of photovoltaics increased from 4% in 2007 to 6.6 % in 2009. Market growth comes because the technology has caught the imagination of everyone, consumers, vendors, governments, politicians, oil producers, and the utility industry. For the first time photovoltaics surpassed the 1% share in the total German energy generation.

Overview of the Photovoltaic Industry in Germany:

- 9.8 GWp total installed PV Power in 2009: 49% of world market and # 1 in volume GWp of newly installed PV capacity, 3.8 GWp in 2009
- EUR 10.2 billion sales in 2009, of which export sales EUR 6.5 billion (= 63% of total sales) - not including income generated from electric energy
- 15-20% expected future annual market growth
- 80,000 employees in 2009; employment growth of over 147% since 2006 (or 50% since 2008)
- 15,000 companies (including small trades and crafts, and equipment manufacturers) are active in the PV field, of which more than 300 are PV cell, wafer or module manufacturers
- more than EUR 190 million investments in R&D in 2008 (significant increase in investments, second largest sector of renewable energies with 22% of total funds)



The world solar Photovoltaic (PV) market installations reached a record high of 6.43 gigawatt (GW) in 2009, representing growth of 5% over the previous year. The PV industry generated 38 billion in global revenues in 2009, while successfully raising over 13.5 billion in equity and debt, up 8% on the prior year.
European countries accounted for 4.75 GW, or 74% of world demand in 2009. The top three countries in Europe were Germany, Italy and Czech Republic, which collectively accounted for 4.07 GW.

PV Industry in Germany

Note: The category PV equipment manufacturers includes PV engineering, manufacturers of cell turnkey lines, module turnkey lines, wet chemistry, vacuum deposition, tabbers, stringers, laminators and automation manufacturers.
Not included are components or accessories manufacturers (such as PV mounting equipment, inverters, cabling, etc.).

There is a cluster of PV (and renewable energy in general) companies in eastern Germany, and particularly in the states of Saxony and its neighboring state Brandenburg due to the fact that investment in this area was strongly encouraged – and subsidized – by the EU and Germany.

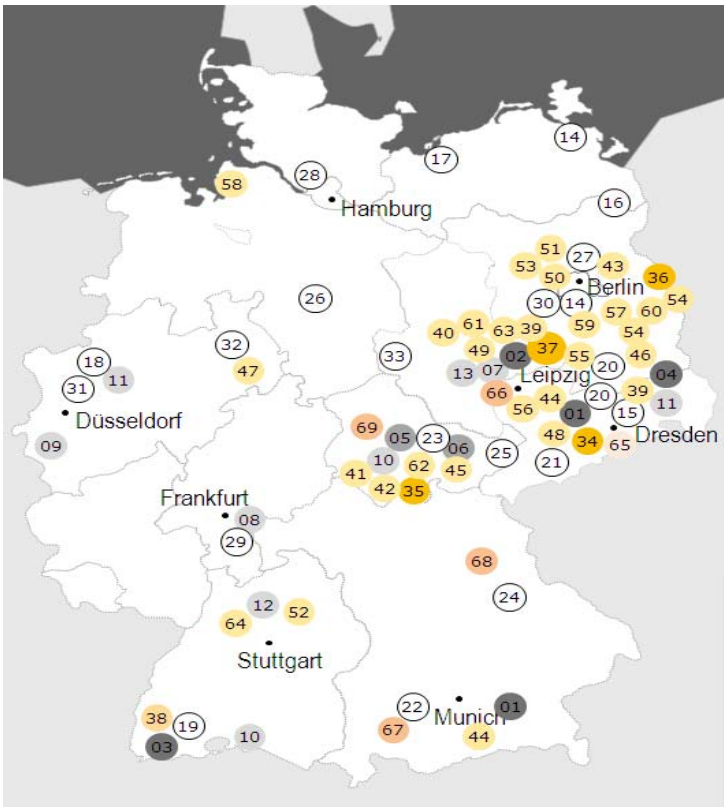


Figure 2: Overview of PV manufacturers in Germany

Germany is the global leader in solar-generated electricity (followed by Japan and the United States), although it is not a "Land of Sunshine" with an average 950 KWh/m2 and year (Spain: 1.300-1.800 KWh/m2 and year). The estimated 2 million solar electricity facilities in Germany have an installed photovoltaic performance of over 9.8 GWp. They produced about 6,200 GWh in 2009 (2008: 4.400 GWh). Almost all PV installations are connected to the grid. Battery-buffered island solutions are only employed in remote areas and in small, free-standing units (e.g., for lighting bus stops or weather or climate measuring equipment).

After Germany that was the leading solar power market in Europe with 67% newly installed photovoltaic output in 2009, market researchers now expect a market share of 25% from the southern European market. EER is expecting an installed PV nominal output of 47 GW by 2020, which implies significant growth in comparison to the currently installed 9 GW. According to EER this requires reliability of solar power feed-in tariffs, long-term national photovoltaic targets and an unsteady development of electricity prices.

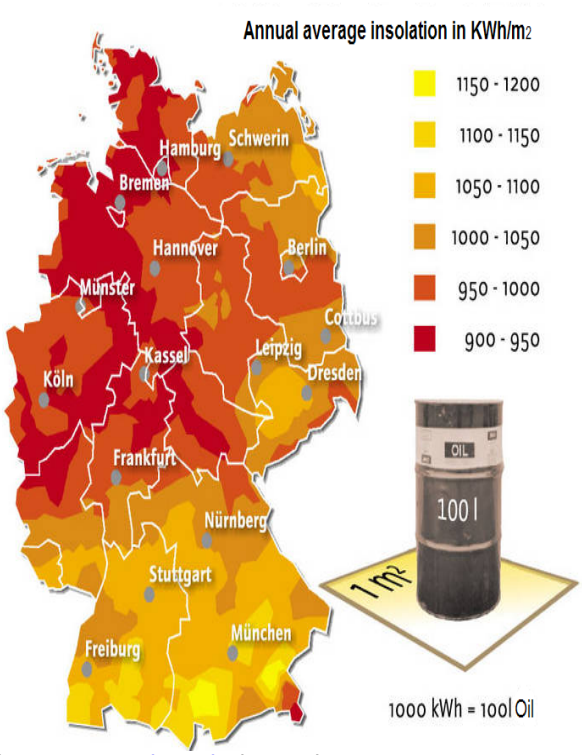


Figure 3: www.dena.de (source)

The Renewable Energy Act (Erneuerbare Energien Gesetz, EEG)

The Renewable Energy Act (Erneuerbare Energien Gesetz, EEG) remains to be the main market driver, which guarantees fixed feed-in tariffs for a 20-year period after installation and grid connection. Grid operators are obliged to connect electricity generation installations to their grids, to purchase electricity available from these installations as a priority, and to compensate the suppliers of this electricity in accordance with EEG provisions.

It is difficult to predict the effects of the latest revision of the EEG on the PV industry in Germany. The considerable reduction of fixed feed-in tariffs starting from July 1, 2010 on, -16% for roof installations and -15% for free standing installations. Moreover, free standing PV installations on arable land will no longer be subsidized.

According to the findings of the Fraunhofer Institute for Solar Energy (ISE), tariff reductions between 6% and 10% are justifiable in the light of decreasing prices for PV installations and will have no effect on demand. Some market experts on the other hand believe that the German PV industry will suffer from declining demand, resulting from the 15% cut in feed-in tariffs, and argue that the resulting decline in domestic demand cannot be compensated by demand from other countries.

Following are the feed-in tariffs for grid connected installations reflecting the digression rates in detail, which are important indicators for price (and interest yield) calculations for manufacturers, as well as end-users.

Year of installation (and connection to grid) January-July 2010				
Feed-in tariff 2010 and for consecutive 20 years	**0-30 kWp € / kWh**	**30-100 kWp € / kWh**	**100 -1000 kWp € / kWh**	**> 1000 kWp € / kWh**
Roof installation + BIPV	0.3914	0.3723	0.3523	0.2937
Free standing installations	0.2843	0.2843	0.2843	0.2843
Year of installation (and connection to grid) from July 1, 2010				
Feed-in tariff 2010 and for consecutive 20 years	**0-30 kWp € / kWh**	**30-100 kWp € / kWh**	**100 -1000 kWp € / kWh**	**> 1000 kWp € / kWh**
Roof installation + BIPV	0.3288	0.3127	0.2959	0.2614
Free standing installations	0.2530	0.2530	0.2530	0.2530
Installations on arable land	0.00	0.00	0.00	0.00
Year of installation (and connection to grid) 2011				
Feed-in tariff 2011 and for consecutive 20 years	**0-30 kWp € / kWh**	**30-100 kWp € / kWh**	**100 -1000 kWp € / kWh**	**> 1000 kWp € / kWh**
Roof installation + BIPV	0.2926	0.2783	0.2634	0.2326
Free standing installations	0.2252	0.2252	0.2252	0.2252
Installations on arable land	0.00	0.00	0.00	0.00

Figure 4: overview of feed-in tariffs according to EEG (German Bundestag: Drucksache 17/1147)

As of 2011, the annual digression will be 9 percent for all module types regardless of installation size. Depending on market development, measured with so called “growth corridors”, the digression rate shall be raised or lowered by two percentage points respectively.

Growth corridor figures:

- 2009: 1.000 - 1.500 MW
- 2010: 1.100 - 3.500 MW
- 2011: 1.200 - 3.500 MW

Considering the amount of already canceled investments and the number of companies getting into financial trouble because of the drastic cutbacks in feed-in compensation, it remains to be seen if the German government will continue to pursue this policy.

Best Prospects

The German photovoltaic market offers various niches for expansion or market entry. One of the most promising trends is performance maximization, which is driven by the desire to increase the return on investment of PV systems. Thus, the demand for residential monitoring and remote maintenance systems, providing real time alarms in case of failures and detection of deficiencies in performance will increase continuously. For the same reason, automatic cleaning systems and water cooling systems for PV modules are expected to have potential. Through either reducing shading or providing the optimal operating temperature, both increase the efficiency of photovoltaic systems.

Because of the rising demand for PV systems throughout Germany, it becomes more important to make every kind of roof accessible for these systems. Consequently new mounting systems for flat and corrugated sheeting roofs seem to have good prospects. Along with increased demand for space, Germans attach greater importance to design issues. In addition to high efficiency, they demand systems that blend in the appearance of their homes, which requires different sizes and innovative types of modules, such as tiles with integrated PV cells or solar thermal elements. For system providers or installation planers planning software offers potential, because it makes finding the optimal solution in terms of module arrangement and efficiency for every customer easier.

Despite demand for improved design, BIPV is currently no big sell in Germany. One reason for this is that the special subsidization for BIPV was suspended in 2008. As integrated systems are more expensive to install, customers choose the cheaper alternative. From the year 2020 on, however, all

new buildings have to be nearly-zero energy buildings. To meet this EU directive issued in November 2009, owners of high buildings may need to integrate PV systems in their façade. Moreover all member states have to set up development schemes for the BIPV sector by midyear 2011.

Another big theme in Germany is diversification. As a result of improved efficiency and reduced production and material costs the market for other materials than silicon is growing. Especially thin film cells made of Copper-Indium-Diselenid (CIS / CIGS) or Cadmium Tellurid (CdTe) will gain in importance, because of their flexibility. Benefiting most from the reduced productions costs for these types of cells, the market for thin film applications for the outdoor sector, e.g. portable battery chargers, island solutions for caravans or cars and other mobile applications, offers good prospects.

The tracker market on the other hand has fallen victim to the sharp decline in module prices. The potential yield of tracker systems is outweighed by the high purchase costs.

The issue of fire protection has become more important, because most fire departments will not put out fires, on roofs with PV installations. The danger of electrification is simply too high. Despite the urgency of the issue, there is still no solution to this problem. Thus innovations like security circuit breakers or systems that can switch of every single module in case of fire or maintenance are in demand.

One recent development is a reaction to the changed feed-in tariffs, which pay additional € 0.08 instead of €0.036 for every kWh consumed by the plant operator and not fed into the grid. In the light of potentially rising electricity prices this makes it more attractive for operators of PV systems to consume the electricity themselves, but at the same time requires a storage unit for solar energy to have the energy available when it is needed.

Worldwide installed PV installations

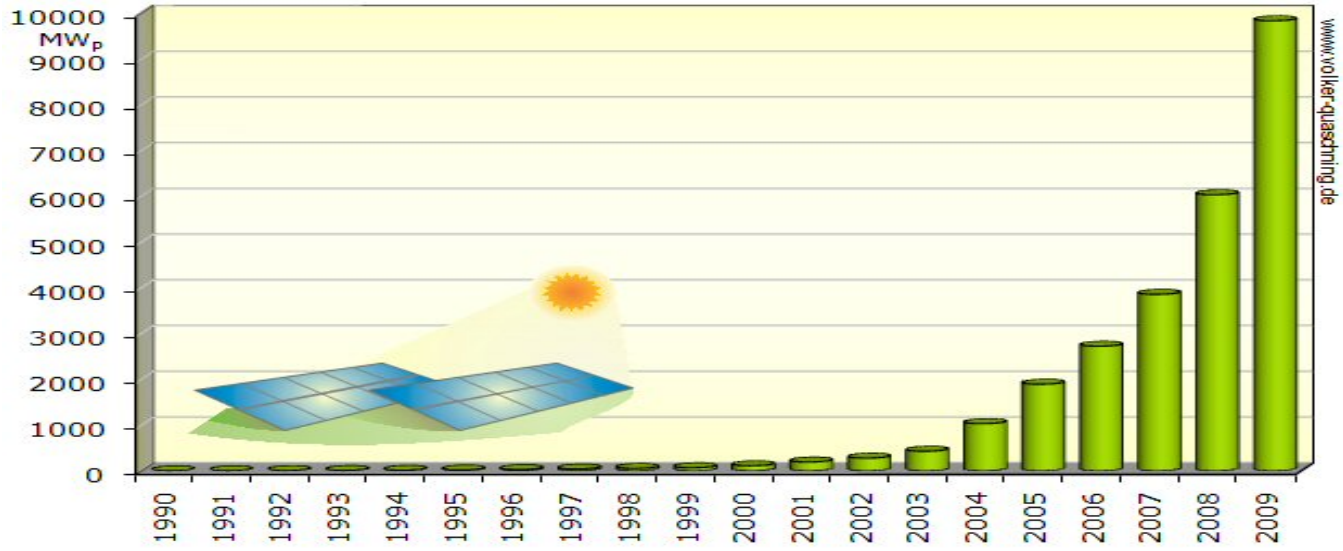


Figure 5: *www.volker-quaschning.de (source)*

German Solar Industry: Sales

(including cells, wafers, modules, components and accessories, not including PV generated electricity compensation)

Year	Sales Photovoltaic Industry (in EUR million)
2003	492 (export share: n/a)
2004	1,645 (export share: 14%)
2005	2,793 (export share: 19%)
2006	4,451 (export share: 34%)
2007	6,100 (export share: 38%)
2008	9,500 (export share: 48%)
2009	9,000 (export share: 60%)

Although German PV module manufactures do not satisfy in-country demand, they sell major quantities to other European markets (e.g. Spain, Italy, France, Greece, and the Benelux countries)

Figure 6: www.solarwirtschaft.de (BSW)

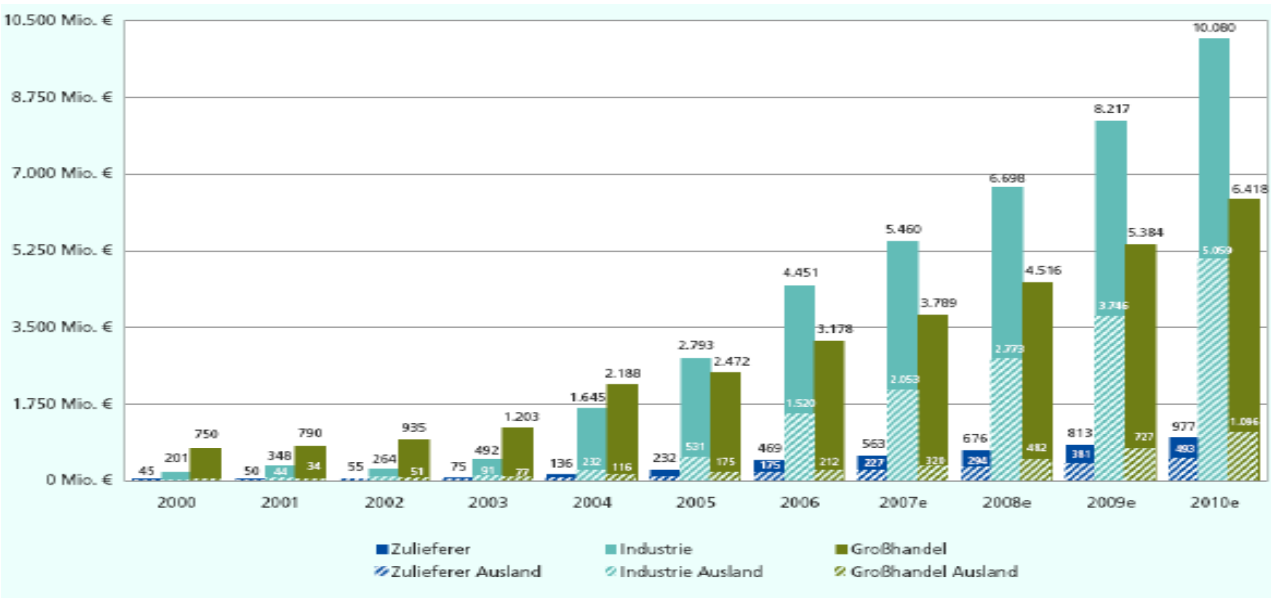


Figure 7: Sales volume of the German PV Industry (source: Standortgutachten EuPD Research/ifo 2008)

Installed Grid-connected PV Capacity

The growth rates in the PV industry are astounding. The kick-off, however, can statistically be clearly demonstrated with the implementation of the EEG (in 2003) when growth rates took off.

Year	New installations	Total (accumulated) installations
1990	0.59 MWp	1.5 MWp
2000	45,8 MWp	113,8 MWp
2001	79MWp	193 MWp
2002	114MWp	307 MWp
003	154 MWp	461 MWp
2004	653MWp	1,114 MWp
2005	931 MWp	2,045 MWp
2006	857 MWp	2,902 MWp
2007	1,110 MWp	4,012 MWp
2008	2.007 MWp	6.019 MWp
2009	3,805 MWp	9.824 MWp

Figure 8**:** *www.volker-quaschning.de (source)*

PV cell production in Germany

Year	Production in MW (all cell types)
1998	2
1999	6
2000	16
2001	33
2002	55
2003	100
2004	190
2005	325
2006	515
2007	835
2008	1380
2009	2456

Figure 9: www.solarwirtschaft.de (BSW)

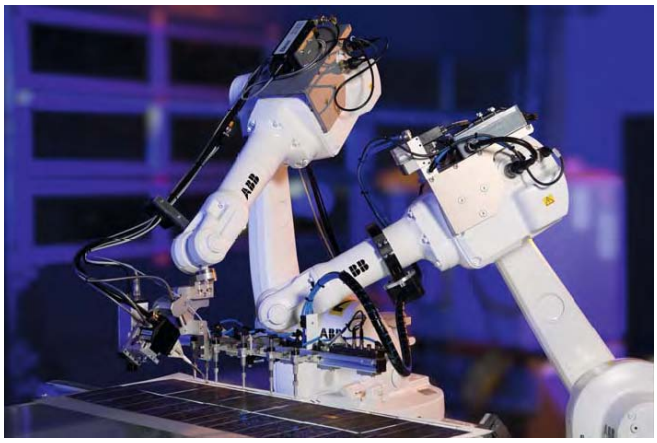


Figure 10: PV cell production (source: www.swissrobotics.net)

PV Cell Types

Germany needs to import a substantial amount of PV cells, wafers, or modules in order to meet domestic demand. All cell types are in demand. More than 90% of all solar cells currently employed use silicone, with crystalline modules (polycrystalline / mc-Si, monocrystalline / c-Si) dominating and thin film solutions (amorphous silicon / a-Si) catching up rapidly.
Other absorber carriers (CIS, CIGS, CIGSSe, CdTe) do not play a major role yet. While this is expected to change in the future, scarce availabilty and costs for certain raw materials which form the basis of alternative absorber carriers (e.g., for indium) may be detrimental to fast deployment. Major investments in “other than silicone” technologies were made by Wuerth Solar (Schwaebisch Hall), CIS Solartechnik (Hamburg) and Sulfurcell (Berlin).

Organic photovoltaic (OPV) is in the advanced testing stage, and has received special R&D grants from the German Ministry of Education and Research (BMBF). Konarka Technologies (New Bedford, Mass.) with its European headquarters in Nueremberg utilizes BMBF programs and is testing Organic Solar Cells (OSC). in ccoperation with several German partners including the University of Tübingen, the University of Wuppertal, Julius-Maximilians-University Würzburg, Ludwig-Maximilians-University Munich and the Max-Planck-Institute for Polymer Research in Mainz.

Figure 11: Test OSC modules

NaCI, GaAs, and TiO2 (also referred to as "Graetzel") cells are mostly used for experimental purposes and in special applications, such as outer space applications.

Pricing

With guaranteed feed-in tariffs and a relatively comfortable planning security insolation rates in Germany, pricing is a decisive factor. In May 2010 pricing for PV modules was as follows (per Watt, excluding mounting costs, installation components, etc.)

Module type / origin	€ / Wp	Change since 01 /10
crystalline (Europe)	1.93	-4.8%
crystalline (China)	1.50	-3.1%
crystalline (Japan)	1.90	-0.3 %
thin film CdS / CdTe	1.57	-2.5%
thin film a-Si / µ-Si	1.36	-1.2 %

Figure12: www.solarserver.de (source)

The significant decrease in prices since 2009, 35% for crystalline modules from Europe / Japan and even 45% for those from China, 20% for thin film modules and 34% for amorphous and micro-crystalline thin film modules, resulted from several factors. According to the Helmholtz Centrum Berlin, the price development for modules is following a "learning curve": when cumulative module output doubles, module prices decrease by 22%. In addition, prices for raw materials went down considerably. Silicon as a main source for PV module manufacturing has plummeted to $55/kg, only one sixth of the price from the beginning of 2008.

As a result of increasing global competition manufacturers are optimizing their material usage, which will lead to further reduction in prices.

Module type	€ / W (system prices excluding VAT)
Thin film technology	2.00 – 3.00
Polycrystalline	2.50 – 3.50
Monocrystalline	2.50 – 9.00
GaAs (three layers)	20.00 – 100.00

Decisive Parameters

In addition to pricing, energy efficiency, life expectancy of the modules and the respective installation location parameters are decisive parameters for purchase decisions.

Most large free-standing PV installations use polycrystalline silicone for their modules. Because module theft is an issue, some larger installations are now also built with less expensive thin film modules, which tend to be larger, more delicate and hence more difficult to de-install. Free standing installations will not experience similar growth rates as in the past for three reasons: 1) feed-in tariffs are much lower and will digress faster than those for on-roof installations, making investments less attractive for financial investors; 2) theft has increased costs for insurance and anti-theft devices (fences, video surveillance, alarm systems); 3) public acceptance for large installations has decreased. Germany is quite populated in its South where alarge installations would make most sense.

The EEG's feed-in tariffs also underline the fact that free standing installations are not favored politically (see above).

Due to weight and pressure concerns, thin film (often on tilted mounted systems) represents the preferred solution for large flat roof installations. The furniture chain IKEA, for example, has announced that it will mount PV modules on all its outlets. IKEA is also considering selling their own PV module brand in their stores. Discounter chains such as ALDI and LIDL are allegedly thinking along the same lines.

For residential and agricultural installations, multi- and polycrystalline modules are clearly leading the sales charts. Yield on limited available space and life expectancy are the decisive major factors here.

For building Integrated PV (BIPV), a mix of all available technologies is employed. New designs and technologies include EVA-laminated, curved plastic or glass fiber modules, or translucent shaped glass modules, in addition to thin film or regular silicone modules. Since BIPV is mostly used in commercial buildings, architectural and visual aspects play a decisive role in purchasing decisions. In general, however, BIPV only accounts for a minor share of the total installed PV equipment in Germany.

Figure 13: Industrial PV covered *Façade in Duisburg-Beeckerwerth*

Components

In order to sell successfully in Germany, it is important to understand the way German roofs are built and covered, and to be familiar with building requirements and laws, which in Germany are regulated on a federal state level. Since PV modules are typically mounted by either carpenters, roofers, or, in some cases, tinsmiths, a potential partner would ideally have such a trade background. Ideally this firm would partner with a local certified electrician, who by law is the only group of professionals entitled to carry out cabling, connecting to inverters, placement of meters, and actual start-up of the installation.

Most private homes in Germany have tiled (concrete or clay) roofs, with a roof pitch of 15-45 degrees. Slate, gneiss, and to a much lesser extent metal sheeting made of zinc, steel, copper or aluminum, and glass are also used.

In northern Germany, thatched roofs are a common sight. Bituminous slates, cement asbestos, corrugated sheeting are mostly used for agricultural or older commercial buildings, troughed (trapezoidal) sheets are today's choice for such structures.
Generally, German clients prefer to purchase from a full service provider, typically an electrician or a system house taking care of the entire installation and regulatory issues (enlisting and registering with the local energy provider, installing the racks and modules, wiring works, installation and set-up of inverters, fixing appointment with the local energy provider for the official connection to the grid, maintenance service contract). In addition to the mandatory 2-year warranty, most module brands offer warranties of up to 25 years with yearly performance digression rates of 0.5-1.5 percent. Typically, the warranty of any present brand name module guarantees 80 percent of the original yield after 20 to 25 years.

PV Industry Market Leaders in Germany:

Silicon	Wacker Chemie PV Crystalox Solar Silicon Joint Solar Silicon
Wafer	SCHOTT Solar Wafer Q-Cells PV Crystalox
Cells	Q-Cells SCHOTT Solar Solland Solar Cells Sunways Arise Technologies
Fully integrated (wafers, cells and modules)	Solarworld Bosch Solar Energy Conergy Sovello
Thin Film	CSG Solar Wuerth Solar Global Solar Sulfurcell Johanna Solar Tech Odersun PVflex Solar Sunfilm
Concentrator (CPV)	Concentrix Solar Solar Tec

Figure 14: Leading PV players produce in Germany *(selection only)* (www.gtai.com)

Trade Events:

One of the most promising avenues of access for U.S. businesses to Germany's energy market is exhibiting or visiting German trade shows. With over 1,700 exhibitors and 60,000 international trade visitors from 145 countries, Europe's leading international event in the solar sector (also featuring the solar thermal industry and solar architecture) is:

Name:	**Intersolar**
Venue:	Munich
Dates:	June 8-10, 2010
Frequency:	annual
Organizer	Solar Promotion, www.intersolar.de

The U.S. Commercial Service will promote U.S. participation at Intersolar and will assist and support U.S. exhibitors and visitors prior, during and after the fair through various programs and counseling.

Solarpeq focuses on solar production equipment including machinery for the production and processing of silicone, wafers, solar cells and modules. It is held parallel to "glasstec". In 2008, it attracted 250 exhibitors from 30 countries and about 55,000 visitors. At a glance:

Name:	Solarpeq
Venue:	Dusseldorf
Dates:	Sep 28 – Oct 1, 2010
Frequency:	annual
Organizer:	Messe Düsseldorf, www.solarpeq.de

In addition to the above listed international energy trade events exclusively devoted to the solar industry, there are a number of international German trade shows covering the photovoltaic industry including:

- E-world energy & water – Essen, February 8-10, 2011 – www.e-world-2010.com
- Hanover Industrial Fair – Hanover, April 4-8, 2011 – www.energy-hannover.de

Resources & Contacts:

Bundesverband Solarwirtschaft (BSW)
(Federal Solar Industry Association)
www.solarwirtschaft.de - website in German only

Deutsche Gesellschaft für Sonnenenergie e.V. (DGS)
(German Solar Energy Society/German Section of Intl. Solar Energy Society-ISES)
http://www.dgs.de - website in German only

Institut für Solare Energieversorgungstechnik (ISET)
(Institute for Solar Energy Supply Technology)
http://www.iset.uni-kassel.de - English website

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