IEA INTERNATIONAL ENERGY AGENCY

National Survey Report of PV Power Applications in GERMANY 2015

PHOTOVOLTAIC POWER SYSTEMS PROGRAMME

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Cover Picture: Solar Plant “Jura” © IBC Solar AG

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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 member countries

The IEA Photovoltaic Power Systems Technology Collaboration 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 participating countries and organisations can be found on the www.iea-pvps.org website.

The overall programme is headed by an Executive Committee composed of one representative from each participating country or organization, 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 promote and facilitate the exchange and dissemination of information on the technical, economic, environmental and social aspects of PV power systems. Task 1 activities support the broader PVPS objectives: to contribute to cost reduction of PV power applications, to increase awareness of the potential and value of PV power systems, to foster the removal of both technical and non-technical barriers and to enhance technology co-operation. 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 country National Survey Report for the year 2015. 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 INSTALLATION DATA

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. Other applications such as small mobile devices are not considered in this report.

For the purposes of this report, **PV installations are included in the 2015 statistics if the PV modules were installed and connected to the grid between 1 January and 31 December 2015, although commissioning may have taken place at a later date**.

1.1 Applications for Photovoltaics

The vast part of German PV-installations is on-grid, the largest part are residential building attached systems. Ground mounted systems represent about one third of total installations.

This structure is a direct result of the Renewable Energy Sources Act (EEG 2014 [1]) being the main driving force of the PV market in Germany. It determines the procedure of grid access for renewable energies and guarantees favourable Feed-in-Tariffs (FiT) for them. The FiT depends on size and type (residential, ground mounted, building integrated, …) of the system.

The low FiT for large ground mounted systems led to the fact that during the last years installation numbers decreased in this market sector. In 2015, the government started tenders for ground mounted systems to push this sector to a more market driven competition (see also 3.3).

A capacity of 1,45 GW PV power has been newly installed in Germany in 2015, staying well below the target corridor of 2,4-2,6 GW (see Chapter 3 Policy Framework). This results into a total installed PV capacity of 39,7 GW connected to the electricity grid. Subsequently, PV contributed 38,5 TWh (approx. 6,4 %) to the annual gross electricity generation of 647,1 TWh [2]. The total amount of electricity generated by grid connected PV systems increased by 6 % in comparison to the previous year [3].

1.2 Total photovoltaic power installed

Since the beginning of 2009 owners of new PV systems are legally obliged to register their systems at the German Federal Network Agency [4]. Another official source is the “Working Group on Renewable Energy Statistics” (AGEE-Stat) [2] working on behalf of the BMWi. This group supplies a lot of data for all renewable energies and PV in detail. Furthermore, the German Solar Association (BSW) supplies data emphasised on the market developments. The fourth source is the “German Trade and Invest (GTI)” collecting data to support foreign investors to enter the German market. Interesting are its list of companies working in the PV market updated quarterly.

There are nearly no information about off-grid non domestic, grid connected centralized systems or stand-alone 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, estimated less than 1 ‰ of grid connected PV capacities and will not be mentioned in this report anymore.

Since 2009 AGEE-Stat employs data of the German Federal Network Agency.

Table 1: PV power installed during calendar year 2015 (Data partly preliminary, taken from **[4]**)

		MW installed in 2015	AC or DC
Grid-connected	BAPV	949	DC
	BIPV (if a specific legislation exists)	No Data (BIPV installations are included in BAPV Data)	
	Ground-mounted	503	DC
Off-grid		No data, numbers are negligible	
Total		**1.452**	DC

Table 2: Data collection process:

Is the collection process done by an official body or a private company/Association?	Public body: Bundesnetzagentur (German Federal Network Agency)
Link to official statistics (if this exists)	www.bundesnetzagentur.de
Data collection Process	All grid connected PV systems have to be registered to the Bundesnetzagentur. Due to the official registration procedure by German Federal Network Agency the accuracy of these data can be assumed better than ± 1 %.

Table 3: PV power and the broader national energy market. [2]

Table 3

GW for capacities and TWh for energy	2015 numbers	2014 numbers
Total power generation capacities (all technologies)	204,5 GW (10.05.2016) [4]	194,2 (29.10.2014)
Total power generation capacities (renewables including hydropower)	97,4 GW	90,1 GW
Total electricity demand (= gross power consumption)	595,1 TWh	591,1 TWh
New power generation capacities installed during the year (all technologies)	N/A	N/A
New power generation capacities installed during the year (renewables including hydropower)	7,3 GW	7,4 GW
Total PV electricity production in GWh-TWh	38,43 TWh	36,1 TWh
Total PV electricity production as a % of total electricity consumption	6,4%	6,1%

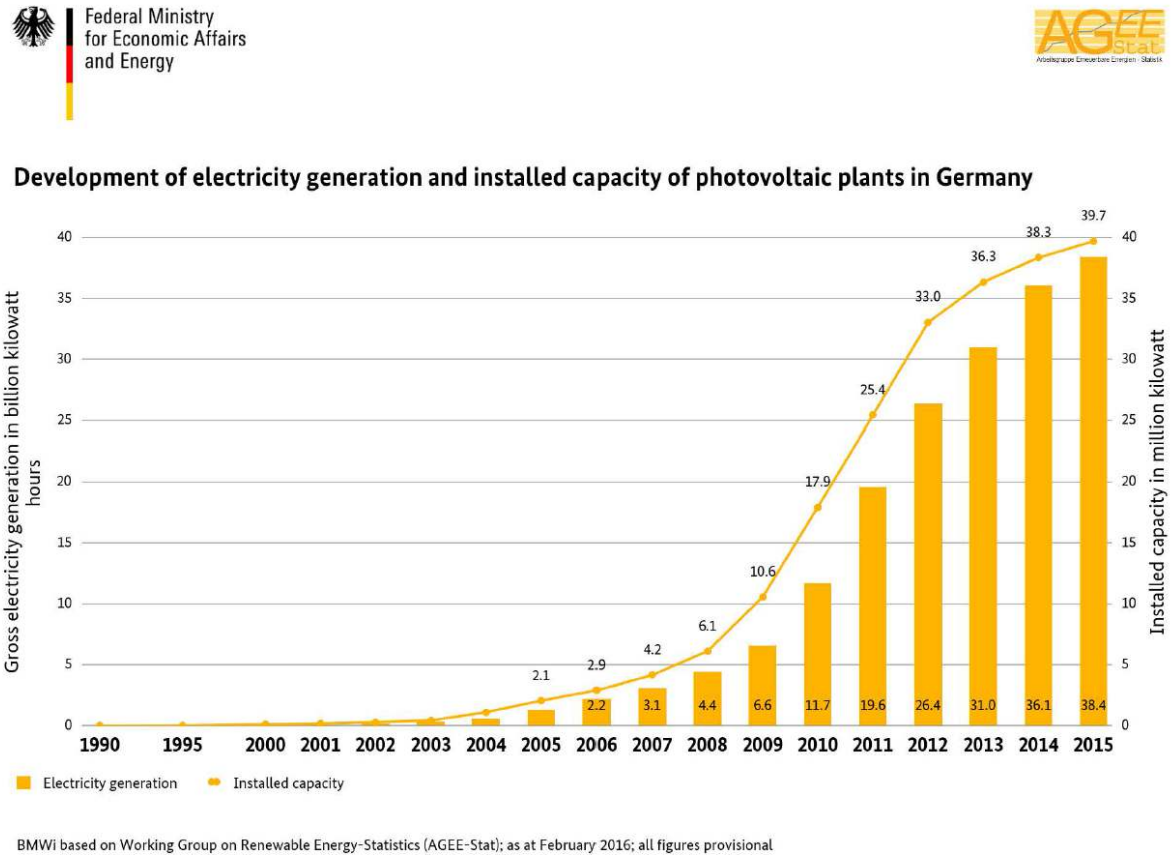
Table 4: Other informations **[5] [4]**

	2015 Numbers
Number of PV systems in operation in your country (a split per market segment is interesting)	**1,53 Million**
Capacity of decommissioned PV systems during the year in MW	**N/A**
Total capacity connected to the low voltage distribution grid in MW	**23,4 GW**
Total capacity connected to the medium voltage distribution grid in MW	**13,6 GW**
Total capacity connected to the high voltage transmission grid in MW	**2,3 GW**

Table 5: The cumulative installed PV power. [2]

Year	Cumulative installed Power [GW]
1990	2 MW
1995	18 MW
2000	114 MW
2001	176 MW
2002	296 MW
2003	435 MW
2004	1,1
2005	2,1
2006	2,9
2007	4,2
2008	6,1
2009	10,6
2010	17,9
2011	25,4
2012	33,0
2013	36,3
2014	38,2
2015	39,7

Figure 1: Development of PV (installed capacity and electricity generation) [2]



2 COMPETITIVENESS OF PV ELECTRICITY

2.1 Module prices

Table 6 shows the module prices (crystalline silicon) on the European spot market from 2010 to 2015. The prices represent the average prices of December of the corresponding year, averages were determined for different module origins (Germany, China, Japan/Korea, Southeast-Asia/Taiwan) resulting in price ranges between 17 and 31 €cent. End-customer prices for an average turnkey PV system can be estimated a factor 2 to 3 higher [6].

Table 6: Typical module prices for a number of years. European spot market prices [€/Wp]. **[6]**

Year	2010	2011	2012	2013	2014	2015
Standard module crystalline silicon price(s) €/Wp	1,55-1,77	0,81-1,12	0,54-0,84	0,52-0,70	0,45-0,62	0,47-0,64

2.2 System prices

Table 7 gives an overview over system prices in different system categories. The prices must be understood as the typical range, individual prices can over- or underrun the given values. Table 8 displays the development of system prices in the past 10 years.
Investments in PV installations are getting attractive even without financial support by a Feed-in-Tariff. A PV rooftop system in the range of 10 – 100 kW cost about 1 300 EUR/kW (average) in 2015

[7]. The Levelized Costs of Energy (LCOE) for such a PV system are around 0,13 EUR/kWh whereas the average electricity price for a private household is around 0,29 EUR/kWh [8].

Table 7: **Turnkey Prices of Typical Applications – local currency**

Category/Size	Typical applications and brief details	Current prices per W
Grid-connected Rooftop up to 10 kW (residential)	Small rooftop systems, mostly for private use, significant share of self-consumption.	1,3-1,7 €/Wp
Grid-connected Rooftop from 10 to 250 kW (commercial)	Large rooftop systems: agricultural or industrial buildings, predominantly for grid injection	1,0-1,7 €/Wp
Grid-connected Rooftop above 250kW (industrial)	-	N/A
Grid-connected Ground-mounted above 1 MW	Ground mounted systems can only be funded if they go through a tendering procedure. The results of the tenders lead to the conclusions, that system prices in this category are well below 1,0 €/Wp.	<1,0 €/Wp

Table 8: National trends in system prices (current) for different applications – local currency [€/kWp]

Price/Wp	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Residential PV systems < 10 KW [9]	4906	4458	4359	3255	2842	2147	1751	1698	1640	N/A
Residential 10kW-100 kW [10]	N/A	4.313	4.135	3.360	2.708	2.185	1.575	1.378	1.325	1.273

2.3 Financial Parameters and specific financing programs

2.3.1 Residential systems

For financing renewable energy systems, the government-owned development bank KfW (Kreditanstalt für Wiederaufbau – Reconstruction Credit Institute) offers – under certain conditions – a loan interest rate of 1%. The maximum credit amount is 50.000 €. In the private sector, several Banks offer specific loans for PV-installations. The interest rates depend on the actual conditions but usually are higher than the KfW rate.

2.4 Additional Country information

Table 12: Country information

Retail Electricity Prices for an household (range)	29,11 €ct/kWh [8]
Retail Electricity Prices for an industrial company (range)	4,32 €ct/kWh [8]
Population at the end of 2014 (or latest known)	82.175684 [3]
Country size (km^2)	357,375 km²
Average PV yield (according to the current PV development in the country) in kWh/kWp	1050 kWh/kWp

3 POLICY FRAMEWORK

This chapter describes the support policies aiming directly or indirectly to drive the development of PV. Direct support policies have a direct influence on PV development by incentivizing or simplifying or defining adequate policies. Indirect support policies change the regulatory environment in a way that can push PV development.

The "Energiewende", the transformation of the energy system is a core task for Germany's environmental and economic policy. The overall objective is an environmental friendly, reliable and economical feasible energy supply. The German Federal Government paved the way for this target when announcing the German Energy Concept in autumn 2010 [11]. Moreover, it was decided in 2011 to terminate the production of nuclear power until 2022. Therefore, the Federal Ministry for Economic Affairs and Energy (BMWi) defined an energy agenda comprising 10 key projects to approach this goal of the energy transition during the 18th legislative term. [12]
The goals are to be reached firstly by efficient energy use and secondly by the use of renewable energies. The German Energy Concept states that renewable energies will contribute the major share to the energy mix of the future. The aim of the German Energy Concept is to reach 18 % of the total gross energy consumption in 2020 (in 2014, 13,7% were reached). Beyond that with respect to the electricity supply, the share for renewable energies shall reach 35% in 2020 (40-45 % in 2025 and 80 % in 2050. With respect to the electricity supply, the share for renewable energies has reached approx. 32,6 % (2014: 27,4%) [2] of the gross electricity consumption of Germany in 2015. This is already close to the first target for 2020 of the Energy Concept.

Photovoltaic reached a share of 6,4% of gross electricity consumption and thus is a major part of this development driven by the Renewable Energy Sources Act (EEG 2014 [1]) on the one hand and a noticeable decrease of system prices on the other hand.

In order to streamline the German energy policies, the responsibility for all energy related activities are concentrated within the Federal Ministry for Economic Affairs and Energy (BMWi).

3.1 Direct support policies for PV installations

3.1.1 New, existing or phased out measures in 2015

3.1.1.1 Description of support measures excluding BIPV, and rural electrification

In terms of achieving expansion targets for renewable energies in the electricity sector, the Renewable Energy Sources Act 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 (FiT) for them. Due to the successful but very fast increase in PV and wind energy generation, and in order to stimulate competition, additional amendments to the EEG have been introduced from August 1st 2014 on.

In the last years, the funding changes stepwise from a classic FiT Model more and more to market driven models. In 2015 there were 3 different models active:

- Classic FiT: System owners could chose this Model for Systems <500 kWp on residential or non residential (lower FiT) Buildings and noise protection Walls. The FiT depends on the system size and whether the system is ground mounted or attached to a building. All FiT-rates are guaranteed for an operation period of 20 years. It includes a monthly adapted degression rate of the FiT, which depends on the previously installed PV capacity (see Table 9).

- Market integration Model: This model can be used for Systems on residential or non-residential (lower FiT) Buildings and noise protection Walls up to 10 MWp. The electricity is sold on the market, a feed-in premium (calculated as the difference between average market price and corresponding FiT) is paid to the electricity producer on top.
- Tenders: For all systems not matching to the limitations of the FiT models (mainly ground mounted systems and systems >10 MWp) there were three calls for tenders: see 3.3

This procedure of "breathing rates" tends to stimulate a yearly installation of 2,4 – 2,6 GW. No further reduction of the FiT was executed from October 2015 on since the installed capacity dropped too far below this range in the corresponding assessment period (see Table 9).

The FiT terminates at a total installed PV capacity of 52 GW. Meanwhile, the EEG contains measures for the integration of PV systems into the grid management.

Since 2014, owners of a newly installed system > 10 kWp have to pay a reduced rate of 30 % of the EEG-surcharge (see also 3.4) for every self-consumed kWh. In 2017 the rate will increase to 40%. Owners of systems below 10 kWp are not affected.

Table 8: Overview: Feed in Tariffs for different system types

Classic Feed in Tariff

System type	Systems on residential rooftops and noise protection walls			Systems on non residential Buildings and ground mounted systems
System size	<10kWp	10-40 kWp	40-500 kWp	<500 kWp
FiT Jan 2015 [€ct]	12,56	12,22	10,92	8,70
FiT Dec 2015 [€ct]	12,31	11,97	10,71	8,53

Market integration Model

System type	Systems on residential rooftops and noise protection walls			Systems on non residential Buildings and ground mounted systems
System Size	<10kWp	10-40 kWp	40-1000 kWp	<10 MWp
FiT Jan 2015 [€ct]	12,95	12,61	11,32	9,09
FiT Dec 2015 [€ct]	12,70	12,36	11,09	8,91

Tenders

	1st call	2nd call	3rd call	
Contracted tariffs [€ct]	8,48-9,42	8,49	8,0	

Table 9: Monthly degression of the feed-in Tariff

Installations in the last 12 months	Monthly change of FiT
>7,5 GWp	-2,8%
6,5-7,5 GWp	-2,5%
5,5-6,5 GWp	-2,2%
4,5-5,5 GWp	-1,8%
3,5-4,5 GWp	-1,4%
2,6-3,5 GWp	-1,0%
2,4-2,6 GWp	-0,5%
1,5-2,4 GWp	-0,25%
1,0-1,5 GWp	0
<1 GWp	+1,5% (per Quarter)

3.1.1.2 BIPV development measures

There were no special measures favouring the development of PV as building element in Germany in 2014.

3.1.1.3 Support for electricity storage and demand response measures

Since 2013 the KfW (see also 2.3.1) is running a market stimulation program to boost the installation of local stationary storage systems in conjunction with small PV systems < 30 kWp. The funding is two-fold: A loan and a grant on the repayment. The first phase ended in 2015 and was limited to a total of 25 MEUR of grants. A second phase will be active from 2016 until end of 2018 with a funding volume of 10 MEUR (grants) per year.

During 2015, the installation of a storage system was funded for 8.796 storage systems (1.267 for existing and 7.529 newly installed PV systems), with the total volume of loans reaching 132 MEUR.

During the first phase (2013-2015), more than 17.000 storage systems were funded. [13] [14]

Table 10: PV support measures (summary table)

	On-going measures residential	Measures that commenced during 2015 - residential	On-going measures Commercial + industrial	Measures that commenced during 2015 – commercial + industrial	On-going measures Ground-mounted	Measures that commenced during 2015 – ground mounted
Feed-in tariffs	Yes	-	Yes	-	-	Only after a Tender
Feed-in premium (above market price)	Yes	-	Yes	-	Yes	-
Self-consumption	yes	-	yes	-	yes	-
Net-metering	-	-	-	-	-	-
Net-billing	-	-	-	-	-	-
Sustainable building requirements		-		-		-
BIPV incentives	-	-	-	-	-	-

3.2 Self-consumption measures

Table 11 gives an overview of the current situation regarding self-consumption in Germany. In general, self-consumption is pushed forward during the last years due to several reasons. Main reasons are the continuous degression of FiT (making self-consumption financially attractive), the degreasing prices of storage systems (leading the possibility of higher self-consumption) and regulatory measures like the limitation of the grid injection to 70% .

Table 11: Self-consumption measures

PV self-consumption	1	Right to self-consume	Yes
	2	Revenues from self-consumed PV	Savings on the electricity bill.
	3	Charges to finance Transmission & Distribution grids	For systems >10 kWp, the “EEG surcharge” (see 3.4) has to be payed on self consumed electricity.
Excess PV electricity	4	Revenues from excess PV electricity injected into the grid	FiT (see 3.1.1.1)
	5	Maximum timeframe for compensation of fluxes	Real time
	6	Geographical compensation	On site only
Other characteristics	7	Regulatory scheme duration	20 years (FiT)
	8	Third party ownership accepted	All

	9	Grid codes and/or additional taxes/fees impacting the revenues of the prosumer	Grid codes compliance and partial EEG surcharge (for systems >10 kWp)
	10	Regulations on enablers of self-consumption (storage, DSM…)	Battery storage incentives
	11	PV system size limitations	Minimum 10% of self-consumption
	12	Electricity system limitations	52 GW of PV installations
	13	Additional features	Systems must be either remotely controllable by network operator or need to limit grid injection to 70% of maximum power.

3.3 Tenders, auctions & similar schemes

In 2015, within the “market integration model” three pilot auctions have taken place for ground-mounted photovoltaic installations, enabling initial experience to be gathered with the new promotion instrument in the field of renewable energies. The aim of the pilot auctions for ground-mounted PV installations is to achieve the expansion targets for renewables in a cost-efficient manner. The pilot auction has ensured that new ground-mounted PV installations are being built while maintaining a high level of public acceptance and stakeholder diversity. The three calls covered a capacity of 500 MW altogether and were characterized by a high degree of competition.
The proposed capacity was significantly over-subscribed and the price level was reduced from call to call (9,17 EURct/kWh -> 8,49 EURct/kWh -> 8,00 EURct/kWh) which shows a good efficiency of the process.

3.4 Financing and cost of support measures

The direct costs of the energy transition to renewables are compensated by the so called EEG levy, paid by the electricity consumers. In 2015 the EEG-levy amounted to 6,17 ct/kWh (2014: 6,24 ct/kWh). There are special treatments for energy intensive industries. [1]

4 HIGHLIGHTS OF R&D

Research and Development (R&D) is conducted under the 6th Programme on Energy Research "Research for an Environmental Friendly, Reliable and Economical Feasible Energy Supply" [15], which came into force in August 2011. Within this framework, the Federal Ministry for Economic Affairs and Energy (BMWi) as well as the BMBF (Federal Ministry of Education and Research) support R&D on different aspects of PV. The main parts of the programme are administrated by the Project Management Organisation (PtJ) in Jülich.

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

4.1.1 Funding activities of the Federal Ministry for Economic Affairs and Energy (BMWi)

In December 2014, the BMWi released a new call for tender, which reflects the targets of the 6th energy research program. Concerning PV, the call addresses six focal points which are all connected to applied research:

- Silicon wafer technology,
- Thin-film technologies, especially based on chalcopyrites (CIS/CIGS),
- Quality control and lifetimes
- System technology for both, decentralised grid-connection and island systems,
- Alternative solar cell concepts such as Concentrated PV (CPV)
- Cross-cutting issues like Building Integrated PV (BIPV), recycling or research on the ecological impact of PV systems.

In 2015 the BMWi support for R&D projects on PV amounted to about 59,68 MEUR shared by 262 projects in total. That year, 106 (2014: 90) new grants were contracted. The funding for these projects amounts to 84,2 (66,9) MEUR in total.
Details on running R&D projects can be found in the BMWi "Annual Report on Research Funding in the Renewable Energies Sector" [16] or via a web-based database of the Federal Ministries. [17]

The German contributions to the PVPS Tasks 1, 12, 13 and 14 are part of the programme.

4.1.2 Funding Activities of the Federal Ministry of Education and Research (BMBF)

From 2013 to 2015, the BMBF funded PV projects under the program "Material Research for the Energy Transition" aiming for the support of long-term R&D which is complementary to the BMWi funding. From September 2015 on, the BMBF relaunched its energy related funding under the "Kopernikus" initiative. Under this scheme cooperative research on four central topics of the "Energiewende" will be addressed: storage of excess renewable energy, development of flexible grids, adaption of industrial processes to fluctuating energy supply and the interaction of conventional and renewable energies.

4.1.3 "R&D for Photovoltaics" – a Joint Initiative of BMWi and BMBF

To support the momentum stimulated by the Innovation Alliance PV of 2010, a new joint initiative of BMWi and BMBF has been launched in 2013. The aim of this 3 year programme "R&D for Photovoltaics" is to support R&D activities especially with participation of the German PV industry in the fields of

- economical operation of grid-connected and off-grid PV system solutions including energy management and storage systems

- efficient and cost effective production concepts including the introduction of new materials and production monitoring systems
- introduction of new PV module concepts with a special focus on quality, reliability and life time.

A mid-term evaluation of the running 12 joint projects which are funded by the ministries BMWi (8 projects, 43 MEUR) and BMBF (4 projects, 6 MEUR) will take place in early 2016. Already now, first results show a significant impact: SolarWorld presented a 22 % record cell efficiency using industrial standard materials and processes only. [18]

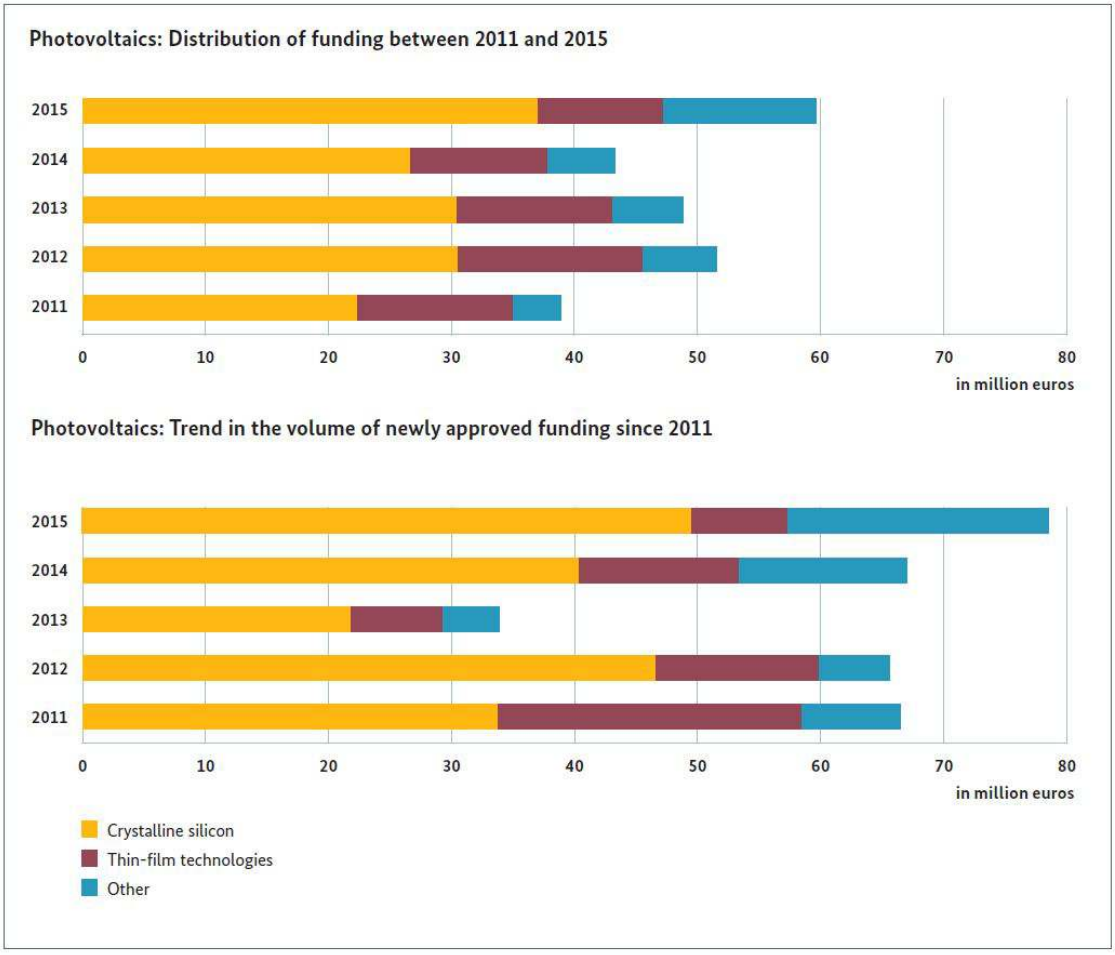


Figure 2: Development of the volume of R&D funding from the Federal Ministry for Economic Affairs and Energy (BMWi) [16]

5 INDUSTRY

The German PV industry manufacturers as well as equipment suppliers are slowly gaining ground. SolarWorld is shifting its whole production processes towards the highly efficient PERC (passivated emitter rear contact) technology. At the same time, material and equipment suppliers experienced a significant upturn in 2015. Holding a share of 50 % [14] of the world market of PV process technologies, equipment suppliers could maintain an excellent position. However, competition with foreign suppliers is becoming more intense. Together with a strong research community and a high number of system installers, a workforce of approximately 40 000 to 50 000 people are employed in the PV industry [19].

In 2015 again the national market leaders underwent important changes: SolarWorld AG took over the production lines from Bosch Solar Energy GmbH in Arnstadt (who stopped production end of 2013) and thus could increase the production capacity for modules in Germany to about 950 MW. Additionally, there is a production capacity for modules of about 550 MW in USA. The production capacity for solar cells in Germany is 1070 MW, in the USA 430 MW, respectively. SolarWorld AG could sell 1108 MW of modules in 2015 which is an increase by about 30 % with respect to 2014. The EBIT improved significantly. Hanwha Q.Cells, which was taken over by the Hanwha Group in 2013, announced in January 2015 to stop the production in Germany

5.1 Production of feedstock, ingots and wafers (crystalline silicon industry)

The main suppliers of silicon feedstock (Wacker Chemie, PV Crystalox Solar Silicon, Schmid Polysilicon Production) kept their production capacity constant during 2015, there are no numbers available on the actual production (see Figure 3). SolarWorld AG announced to restart silicon feedstock production during 2015 in the former Bosch Solar line in Arnstadt that closed down end of 2013.

5.2 Production of photovoltaic cells and modules (including Thin Films - TF and Concentrator Photovoltaics - CPV)

Figure 3 gives an overview of the Solar Cell and Module manufacturers with production capacity and number of employees. Data of the actually produced number of modules is not available for 2015.

5.3 Manufacturers and suppliers of other components

Due to the well-developed PV industry all components for an entire PV system are available in Germany. An excellent overview is given by the “Fact Sheet” of “Germany Trade and Invest” [19]:

- Fact Sheet - Photovoltaic BOS Components [PDF, 397 KB]
- Fact Sheet - Photovoltaic Equipment [PDF, 508 KB]
- Fact Sheet - Photovoltaic Manufacturers [PDF, 357 KB]
- Fact Sheet - Photovoltaic Module Materials [PDF, 346 KB]
- Fact Sheet - Photovoltaic R&D [PDF, 413 KB]
- Fact Sheet - Solar Thermal Industry in Germany [PDF, 155 KB]
- Germany: Lead Market for Energy Storage & Fuel Cell Systems [PDF, 4668 KB]

For details see the website of the companies.

Photovoltaics—Made in Germany

GTAI GERMANY TRADE & INVEST

Leading PV Manufacturers in Germany

October 2016

Value Chain	No.	Company*	Locations	Production Capacity [MWp]	Empl.**
Silicon	Ae	Schmid Polysilicon Production GmbH	Spreetal	180t	S
	Si	Silicon Products Group	Bitterfeld-Wolfen	1,800t	M
	Wa	Wacker Chemie AG	Burghausen, Nünchritz	n/a	L***
Cells	Ae	aleo sunrise GmbH	Prenzlau	100	n/a
Modules	Ae	aleo solar GmbH	Prenzlau	320	n/a
	AL	ALGATEC Solarwerke Brandenburg GmbH	Prösen, Großräschen	25	S
	Ao	asola Technologies GmbH (TUSAI Holding)	Erfurt	40	S
	As	Astrongery Solar Module GmbH	Frankfurt (Oder)	300***	n/a
	At	Axitec Energy GmbH & Co.KG	Böblingen	300	S
	Ax	AxSun Solar GmbH & Co.KG	Laupheim-Baustetten	70***	n/a
	CS	CS Wismar GmbH (Sonnenstromfabrik)	Wismar	n/a	n/a
	GS	GSS Gebäude-Solarsysteme GmbH	Korbußen	20	S
	He	Heckert Solar GmbH	Chemnitz	300	M
	Hö	Hörmann Novo Solar GmbH	Laubusch	10	S
	ML	ML&S GmbH	Greifswald	Up to 200	n/a
	Si	SI Module GmbH	Freiburg	25	S
	Sk	Solarfabrik CL GmbH	Freiburg	n/a	S
	Sl	Solarnova GmbH	Wedel	35	S
	So	Solarwatt GmbH	Dresden	250	M
	St	Soluxtec GmbH	Bitburg	n/a	S
	Su	Sunset Solar GmbH & Co.KG	Löbichau	40	S
	Sw	Sunware Solartechnik GmbH & Co.KG	Duisburg	n/a	S
Fully integrated	Sd	Solarworld AG	Arnstadt	700 (cells); 200 (modules)	L
	Sd	Solarworld AG	Freiberg	330 (cells); 660 (modules); 750 (wafer)	L
CIGS	Av	Avancis GmbH (CNBM International)	Torgau	100	L
	Ma	Manz CIGS Technology GmbH	Schwäbisch Hall	6	M
	So	Solibro GmbH (Hanergy)	Bitterfeld-Wolfen	120***	n/a
CdTe	Ca	Calyxo GmbH (Solar Fields LLC)	Bitterfeld-Wolfen	85	M
GaAs	Az	Azur Space Solar Power GmbH	Heilbronn	n/a	M***
OPV	He	Heliatek GmbH	Dresden	Currently R&D; full production to start 2018	

Notes:

Click on the company name to reach the respective homepage.

Please find a map with the locations of the companies on the back side of this document.

* This list is not intended to be exhaustive.
** Number of employees in Germany:
S (small): ≤50 employees
M (medium): 51—250 employees
L (large): >250 employees
*** Information from company website

Figure 3: Overview on the leading producers of silicon, wafers, cells and modules in Germany [19].

5.4 Manufacturers and suppliers of other components

A close cooperation of manufacturers, suppliers and global research leaders is one main advantage of the German PV industry. The outcome of this is that the technology and value chain can be completely covered in the German solar cluster. Figure 4 and Figure 5 list the leading suppliers of PV systems - including tracking systems – in Germany [19]. Updated data for the year 2015 is currently not available.

PV Balance of System

Leading Manufacturers of PV System Components Produce in Germany February 2013

Component	No.	Company	Locations	Capacity 2012 [MWp]	Empl. *
Inverters	01	AEG Power Solutions	Warstein-Belecke	n/a	680
	02	Bonfiglio Vectron	Krefeld	n/a	112
	03	Converteam	Berlin	n/a	700
	04	Diehl AKO	Wangen	700	140
	05	Dorfmüller Solaranlagen	Kernen	5	5
	06	Enecsys Europe	Bad Homburg	n/a	6
	07	FBG	Sömmerda	<1	11
	08	Ingeteam	Hamburg, München	2000	350
	09	KACO new energy	Neckarsulm	1200	400
	10	KOSTAL Industrie Elektrik	Hagen	n/a	190
	11	LTI REEnergy	Unna	500	250
	12	M+W Group	Crailsheim **	100	50
	13	PCS Power Converter Solutions GmbH	Berlin	n/a	250
	14	REFU Elektronik	Metzingen	n/a	170
	15	SMA Solar Technology	Niestetal, Kassel	10000	4000
	16	Solutronic	Großbettlingen	250	30
	17	Sputnik Engineering	Neuhausen auf den Fildern	1600	21
	18	Steca Elektronik	Memmingen	40	510
	19	Sunways	Konstanz	n/a	145
	20	Bosch Power Tec	Hamburg	250	100
Cables	21	badea	Aßlar, Herborn		320
	22	Draka Cable Wuppertal	Wuppertal		500
	23	HELUKABEL	Windsbach		450
	24	HEW-KABEL	Wipperfürth		320
	25	HI Kabelkonfektionierung	Beerfelden		120
	26	HUBER+SUHNER	Taufkirchen		140
	27	KBE Elektrotechnik	Berlin		220
	28	Klasing Kabel	Denkendorf		170
	29	KWV Kabelwerke	Villingen-Schwenningen		90
	30	Lumberg Connect	Schalksmühle, Cloppenburg		1000
	31	Multi-Contact	Weil am Rhein		120
	32	Nexans	Hannover		400
	33	PRYSMIAN	Eschweiler, Schwerin		110
	34	Sykonec	Neustadt bei Coburg		42
	35	Tyco Electronics	Bensheim		1950
	36	U.I. Lapp	Stuttgart		800
	37	VOKA	Plauen, Falkenstein		500
	38	XBK-Kabel	Rottweil		200
	39	Yamaichi Electronics	Frankfurt (Oder)		150
Connectors	40	Amphenol-Tuchel	Heilbronn		300
	41	Büschel	Jungingen		30
	42	Citel	Bochum		130
	43	HI Kabelkonfektionierung	Beerfelden		120
	44	Hirschmann	Neckartenzlingen, Ettlingen, Schalksmühle		350
	45	Huber + Suhner	Taufkirchen		200
	46	Huonker	Villingen-Schwenningen		100
	47	Lumberg Connect	Schalksmühle, Cloppenburg		800
	48	Molex	Bretten		80
	49	Multi-Contact	Weil am Rhein		120
	50	Pöppelmann Kunststoff-Technik	Lohne		350
	51	U.I.Lapp GmbH	Stuttgart		800
	52	Wieland Electric	Bamberg		1000
	53	Yamaichi Electronics	Frankfurt (Oder)		150

*) Total number of employees at respective locations
**) OEM production
Source: Germany Trade & Invest, Information provided by the respective company, February 2013

The Market

Germany is the world's largest PV market with more than 32.4 GWp of cumulated PV power in 2012, 7.6 GWp of which were newly installed in 2012 alone.

Local manufacturers of PV Balance of System components such as inverters, cables, connectors and mounting and tracking systems benefit especially from the proximity to the world's largest PV market.

"Made in Germany" components enjoy a high international reputation in terms of both reliability and performance.

In 2011, 35 percent of PV inverters produced worldwide were manufactured in Germany. 80 percent of all inverters installed in Germany in 2011 were produced locally.

GERMANY TRADE & INVEST

Figure 4: Overview on the leading suppliers for PV mounting and tracking systems in Germany – Part 1 [19].

PV Balance of System

Leading Manufacturers of PV Mounting & Tracking Systems in Germany

February2013

System	No.	Company	Locations	Empl.*
Tracking Systems - own manufacturing	54	a+f	Würzburg	109
	55	DEGERenergie	Horb	30
	56	Eggert	Oberstadion	25
	57	EGES-Equipment	Offenbach	5
	58	EQ-SYS	Treuenbrietzen	21
	59	Galaxy Energy	Heroldstatt	35
	60	Green Factory	Heidenheim	10
	61	GSM Solar	Memmingen	90
	62	Harow Solar	Wismar	12
	63	IMO Anlagenbau	Gremsdorf	50
	64	Kemper	Vreden	100
	65	Bernt Lorentz	Hensbedt-Uetzburg	25
	66	Löseke & Marx Maschinenbau	Paderborn	30
	67	mp-tec	Eberswalde	70
	68	PV-Etwa	Plattling	100
	69	PVStrom Energy Systems	Kirchheim am Neckar	25
	70	Schüco International	Bielefeld	1500
	71	Altec Solartechnik	Sömmerda	70
	72	Solarpark Rödeniß	Rodeniß	50
	73	Solea	Plattling	29
	74	sonnen_systeme	Alheim-Heinebach	100
Tracking Systems - OEM production in Germany	75	Energiebau Solarstromsysteme	Köln	300
	76	IDEEMATEC	Wallerfing	16
	77	RWenergy	Schwandorf	30
	78	S+S Energietechnik	Lüchow-Grabow	5
	79	Solar-Track	Lübeck	10
	80	Bosch Power Tec	Hamburg	100
Mounting Systems - own manufacturing	81	ALTEC Solartechnik	Crispendorf, Sömmerda	185
	82	Bertz Alusysteme	Ingersheim	15
	83	CEKO	Nersheim	15
	84	EQ-SYS	Treuenbrietzen	20
	85	Fath Solar	Spalt	100
	86	Grammer Solar	Amberg	50
	87	Metall Josten	Düsseldorf	25
	88	Mounting Systems (Conergy)	Rangsdorf	250
	89	mp-tec	Eberswalde	70
	90	MÜPRO**	Hofheim-Wallau	n/a
	91	Niemetz Metall	Königsfeld	50
	92	PV-Etwa	Plattling	100
	93	RegTec	Augsburg, Wiesthal, Bad Berka	20
	94	Schletter	Kirchdorf	400
	95	Solarpark Rodeniß	Rodeniß	50
	96	Solarstep	Königstein	6
	97	Soltech**	Bielefeld	15
	98	TS-Aluminium	Großefehn, Burgstädt	85
	99	VM Edelstahltechnik	Pfetterberg	20
	100	Wagener & Simon	Wuppertal	150
	101	Wagner & Co. Solartechnik	Cölbe	400
	102	Wilhelm Flender	Netphen	75
	103	Zambelli	Grafenau	650
	104	Zentralasier	Rheine	25
	105	Zinco	Unberenlingen	70
Mounting Systems - OEM production in Germany	106	alfasolar	Hannover	40
	107	E.u.r.o Tec**	Hagen	30
	108	ECOSOLAR	Duisburg	9
	109	Energiebau Solarstromsysteme	Köln	300
	110	HABDANK PV-Montagesysteme	Göppingen	40
	111	HELTRON**	Breisach	19
	112	IDEEMATEC	Wallerfing	16
	113	K2 Systems	Well der Stadt	45
	114	PanelClaw	Wuppertal	23
	115	Renusol**	Köln	90
	116	RWenergy	Schwandorf	30

*) Total number of employees at respective locations
**) Some components only engineered in Germany

Source: Germany Trade & Invest,
Information provided by the respective company,
February 2013

About Us

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Figure 5: Overview on the leading suppliers for PV mounting and tracking systems in Germany – Part 2 [19].

6 PV IN THE ECONOMY

6.1 Labour places

From 2013 to 2014 the total amount of employees in the field of renewable energy decreased from 371.400 to 355.400 (see Table 12) [20]. Only in the sectors “wind onshore”, “near surface thermal energy” and “biomass combined heat and power plant” the number of employees could be slightly increased. The most significant reduction is observed for the sector of “photovoltaics”.

The long term development in Germany’s renewable energy sector is shown in Figure 6 [20]. After a peak in the year 2012 (399.800 employees) the amount of employees has been reduced down to 355.400 in the year 2014. However, this is still more than doubling compared to 2004. Most affected by external circumstances (e. g. market development) is the sector of “solar energy”.

	Employees in 2013	**Employees in 2014**
Wind Onshore	119.000	130.500
Wind Offshore	18.800	18.700
Photovoltaics	56.000	38.300
Solar thermal	11.400	10.300
Solar thermal power plants	1.100	700
Hydropower	13.100	11.800
Deep thermal energy	1.500	1.100
Near surface thermal energy	15.800	16.100
Biogas	49.200	48.300
Biomass (small plants)	28.600	25.400
Biomass combined heat and power plant	23.000	23.100
Biofuel	25.600	23.100
Publicly funded research / administration	8.300	8.000
In total	**371.400**	**355.400**

Table 12: Development of Germany’s gross employment, subdivided in the different categories of renewable energy within the years 2013/2014. (adapted from [20]).

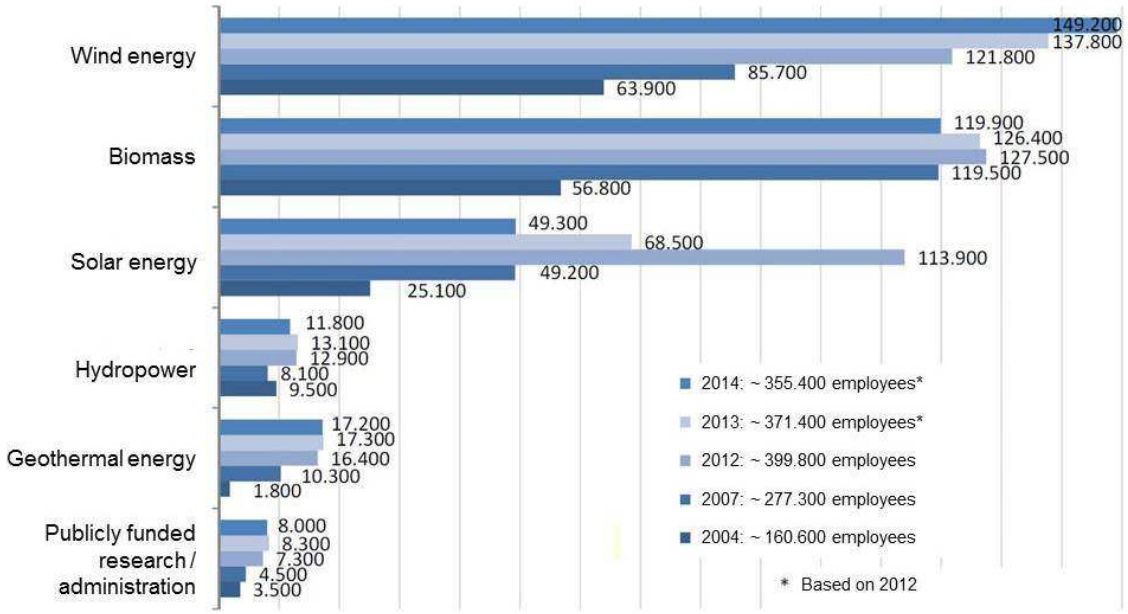

Figure 6: Long term development of gross employment in Germany's renewable energy sector (adapted from [20]). Updated data for 2015 is not available.

7 INTEREST FROM ELECTRICITY STAKEHOLDERS

7.1 Structure of the electricity system

The electricity market and production is dominated by the 4 large enterprises:

- EON (Transmission Grid: Tennet TSO GmbH)
- RWE
- Vattenfall
- EnBW

Additionally there are city owned companies and industrial producers for their own facilities. The four market leaders hold 67,6% of the production capacities and reached a share of 76,2% regarding the produced electricity.[1]

The high voltage transmission grid originally was also controlled by the 4 large electricity companies. By now, three of them have sold their transmission grid operating companies, only EnBW is still running their own grid. Figure 7 shows the control areas of the four transmission grid operators:

- Tennet TSO GmbH
- Amprion GmbH
- 50Hertz Transmission GmbH
- TransnetBW GmbH

The total transmission grid length summed up to 36.001 km in 2015 [21].

Figure 7: The high voltage transmission grid operators **[22]**.

The final distribution to the customers is carried out by 817 distribution network operators (DNO), controlling a grid length of 1.780.856 km [21]. Most of the distribution networks belong to municipal energy suppliers, but some belong to private companies.

[1] Electricity production without EEG-electricity. This means in particular, that most renewable electricity sources are not included in the calculation. Due to the availability of data, a part of the EEG-electricity under direct marketing is included.

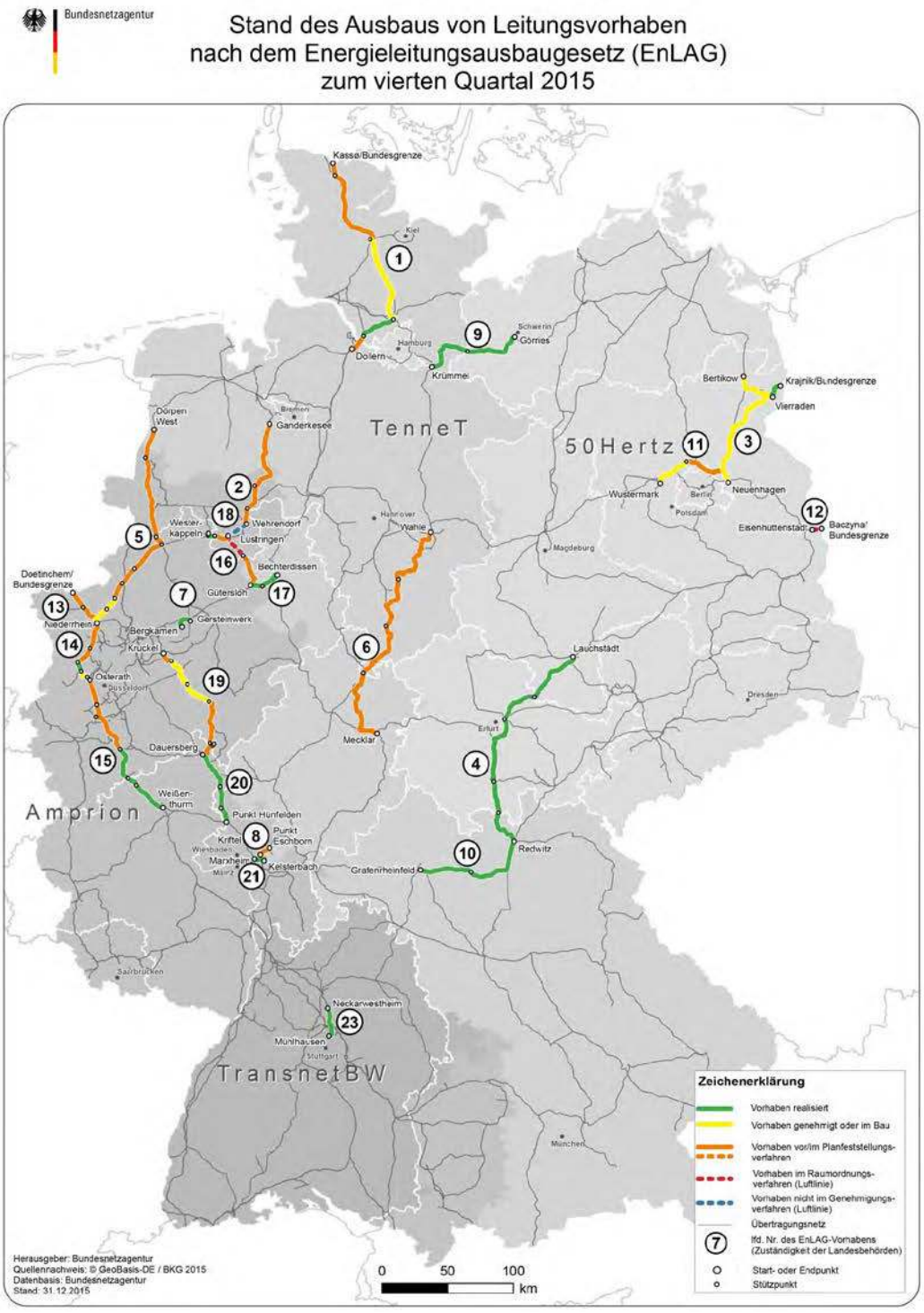

Figure 8: Status of the expansion of energy lines pursuant to the Energy Line Extension Act (EnLAG) **[4]**. Green lines: *Completed*. Yellow lines: *Approved or under construction*. Orange lines and dashed orange lines: *Prior to or in planning procedure*. Dashed blue lines: *Not in planning procedure*.

The Bundesnetzagentur (Federal Network Agency) is Germany's regulatory authority for the electricity, gas, telecommunications, postal and rail markets. Since 2011, it has also taken on responsibility for implementing the Grid Expansion Acceleration Act (NABEG) [19] [23].

7.2 Interest from electricity utilities

The interest of the 4 large enterprises EON, RWE, Vattenfall and EnBW for the installation of PV power plants seems to be still rather conservative. Driven by the regulatory framework, they increase their engagement in renewables, but the main focus is in the wind sector. The PV market is dominated by the private sector for roof-top systems and by project developers for ground mounted systems.

Still, due to the large variety of companies in the German energy market, there are numerous concepts from local energy suppliers. Most of the energy suppliers offer green electricity tariffs for their customers and operate their own renewable systems and/or support private PV systems. Among the nationwide acting companies, there are some who only sell electricity from renewables.

8 REFERENCES

[1] „Renewable Energy Sources Act (EEG),“ [Online]. Available: http://www.bmub.bund.de/fileadmin/bmu-import/files/english/pdf/application/pdf/eeg_2012_en_bf.pdf.

[2] „Development of renewable energy sources in germany 2015, Based on statistical Data from the Working Group on Renewable Energy-Statistics (AGEE-Stat),“ 2016. [Online]. Available: www.erneuerbare-energien.de.

[3] Federal Statistical Office (Statistisches Bundesamt), [Online]. Available: www.destatis.de.

[4] „Bundesnetzagentur / German Federal Network Agency,“ [Online]. Available: http://www.bundesnetzagentur.de/cln_1432/EN/Home/home_node.html.

[5] „BSW Solar,“ [Online]. Available: www.solarwirtschaft.de.

[6] „pvXchange,“ [Online]. Available: http://www.pvxchange.com/priceindex/Default.aspx?template_id=1&langTag=en-GB.

[7] Fraunhofer Institute for Solar Energy Systems ISE, „Recent facts about photovoltaics in Germany“.

[8] German Federal Ministry of Economic Affairs and Energy (BMWi), „Energie der Zukunft,“ 2015.

[9] „photovoltaik.org,“ [Online]. Available: http://www.photovoltaik.org/wirtschaftlichkeit/photovoltaik-preise. [Zugriff am Jan 2016].

[10] „Statista,“ [Online]. Available: www.statista.com.

[11] „Energy Concept for an Environmentally Sound, Reliable and Affordable Energy Supply,“ [Online]. Available: http://www.germany.info/contentblob/3043402/Daten/3903429/BMUBMWi_Energy_Concept_DD.pdf.

[12] Federal Ministry for Economic Affairs and Energy (BMWi), „10-point energy agenda,“ [Online]. Available: http://www.bmwi.de/English/Redaktion/Pdf/10-punkte-energieagenda,property=pdf,bereich=bmwi2012,sprache=en,rwb=true.pdf.

[13] Zentrum für Sonnenenergie- und Wasserstoffforschung Baden-Württemberg (ZSW), „Evaluierung der inländischen KfW-Programme zur Förderung Erneuerbarer Energien in den Jahren 2013 und 2014 - Gutachten im Auftrag der KfW Bankengruppe,“ 2015.

[14] KfW Bankengruppe, „Förderreport“.

[15] Federal Ministry for Economic Affairs and Energy (BMWi), [Online]. Available: http://www.bmwi.de/DE/Themen/Energie/Energieforschung-und-Innovationen/6-energieforschungsprogramm.html.

[16] „Innovation Through Research-Renewable Energies and Energy Efficiency: Projects and Results of Research Funding in 2015, BMWi,“ http://www.bmwi.de/EN/Service/publications.html.

[17] „Research project database (in German),“ [Online]. Available: http://foerderportal.bund.de.

[18] „Solarstromforschung,“ [Online]. Available: http://www.solarstromforschung.de/.

[19] „German Trade & Invest (GTAI),“ [Online]. Available: www.gtai.de.

[20] „Bruttobeschäftigung durch erneuerbare Energien in Deutschland und verringerte fossile Brennstoffimporte durch erneuerbare Energien und Energieeffizienz,“ [Online]. Available: http://www.bmwi.de/DE/Mediathek/publikationen,did=739134.html.

[21] Bundesnetzagentur/Bundeskartellamt, „Monitoringbericht 2016,“ 2016.

[22] „Wikipedia - Netzentwicklungsplan,“ [Online]. Available: https://de.wikipedia.org/wiki/Netzentwicklungsplan.

[23] „Second Monitoring Report “Energy of the future” Summary, BMWi,“ [Online]. Available: http://www.bmwi.de/EN/Service/publications,did=639404.html.