IEA INTERNATIONAL ENERGY AGENCY

TRENDS 2013

IN PHOTOVOLTAIC APPLICATIONS

Survey Report of Selected IEA Countries between 1992 and 2012

PVPS

PHOTOVOLTAIC
POWER SYSTEMS
PROGRAMME

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Cover Picture: ISSOL, Perpignan Train Station, France.

CHAPTER 1 – PV Technology and Applications

IEA PVPS is proud to present the 18th edition of the international survey report on Trends in Photovoltaic (PV) Applications up to 2012. The "Trends Report" is one of the flagship publications of the IEA PVPS Programme, documenting the evolution of PV applications within its member countries as well as worldwide. Providing detailed insight and analysis of the PV market development, the series of trends reports published since nearly 20 years are a unique repository of the evolution of the global PV market and its framework. Over this period of time, PV has evolved from a pure niche market of small scale applications towards becoming a mainstream electricity source. Observing the recent PV market evolution, 2012 may well prove to be a turning point for PV in different aspects. After many years of continuous and strong growth, remaining at a high level of the previous year, the global PV market has stabilized in 2012. While in some countries, the PV market continues to grow, it has become smaller in Europe on the whole. At the same time, PV markets in Asia have grown substantially and will likely continue to do so over the coming years. Overall, 25,3 GW of PV were installed in IEA PVPS member countries during 2012 (2011: 28 GW), whereas the global PV market is estimated at 29,3 GW. The global installed total PV capacity reached at least 96,6 GW at the end of 2012, approaching the 100 GW level. Following on the development of the previous year, prices for PV systems continued to drop very quickly, partly due to overcapacity of PV modules on the market. This has allowed new markets and market segments to develop but has also introduced a painful consolidation phase for the industry; pushing many companies out of business and leading to a substantial reshuffling of the major players. During 2012, feed-in tariffs remained the main driving force of the worldwide PV market but self-consumption, net-metering and new business models have started to come into play. Overall, this is an encouraging sign for the growing competitiveness of PV and the increasing occurrence of self-sustained markets. In countries with high levels of installed capacity, PV has started to affect the electricity markets, technically and quantitatively, as well as economically. It has become evident that the integration of PV in the electrical grid from a technical point of view, as well as in the electricity market from an economic point of view, has become major issues which need to be solved in the coming years. Finally, at the levels of deployment reached, questions of sustainability are becoming more relevant in all dimensions, e.g. regarding recycling. A comprehensive system view is thus becoming ever more important. All these dynamic developments are encouraging signs of a growing and more mature market with some key issues to be resolved. In parallel, efforts in research, development and innovation are rapidly yielding new technological solutions and opening up new market segments. I hope that you will find reading about all these dynamic developments of a rapidly growing new energy technology as exciting as I do!

Stefan Nowak
Chairman, IEA PVPS Programme

Introduction

PV markets have significantly progressed outside Europe for the first time in 2012. While the market stabilized globally, the PV industry was put under heavy cost pressure. The price decrease of PV modules and system is opening new opportunities, in both grid-connected and off-grid applications. This report aims at providing a comprehensive analysis of the PV market evolution, together with the policy support for PV applications. The PV industry, its impact on the economy in general and the electricity sector in particular, are at the center of this 18th IEA PVPS Trends report.

Report Scope and Objective

As part of the work of the IEA PVPS Programme annual surveys of photovoltaic (PV) power applications and markets are carried out in the reporting countries. The objective of the Trends reports is to present and interpret developments in the PV power systems market and the changing applications for these products within that market. These trends are analyzed in the context of the business, policy and non-technical environment in the reporting countries.

This report is prepared to assist those responsible for developing the strategies of businesses and public authorities, and to aid the development of medium term plans for electricity utilities and other providers of energy services. It also provides guidance to government officials responsible for setting energy policy and preparing national energy plans.

The scope of the report is limited to PV applications with a rated power of 40 W or more. National data supplied are as accurate as possible at the time of publication. Accuracy of data on production levels and system prices varies depending on the willingness of the relevant national PV industry to provide data.

This report presents the results of the 18th international survey. It provides an overview of PV power systems applications, markets and production in the reporting countries and elsewhere at the end of 2012 and analyzes trends in the implementation of PV power systems between 1992 and 2012.

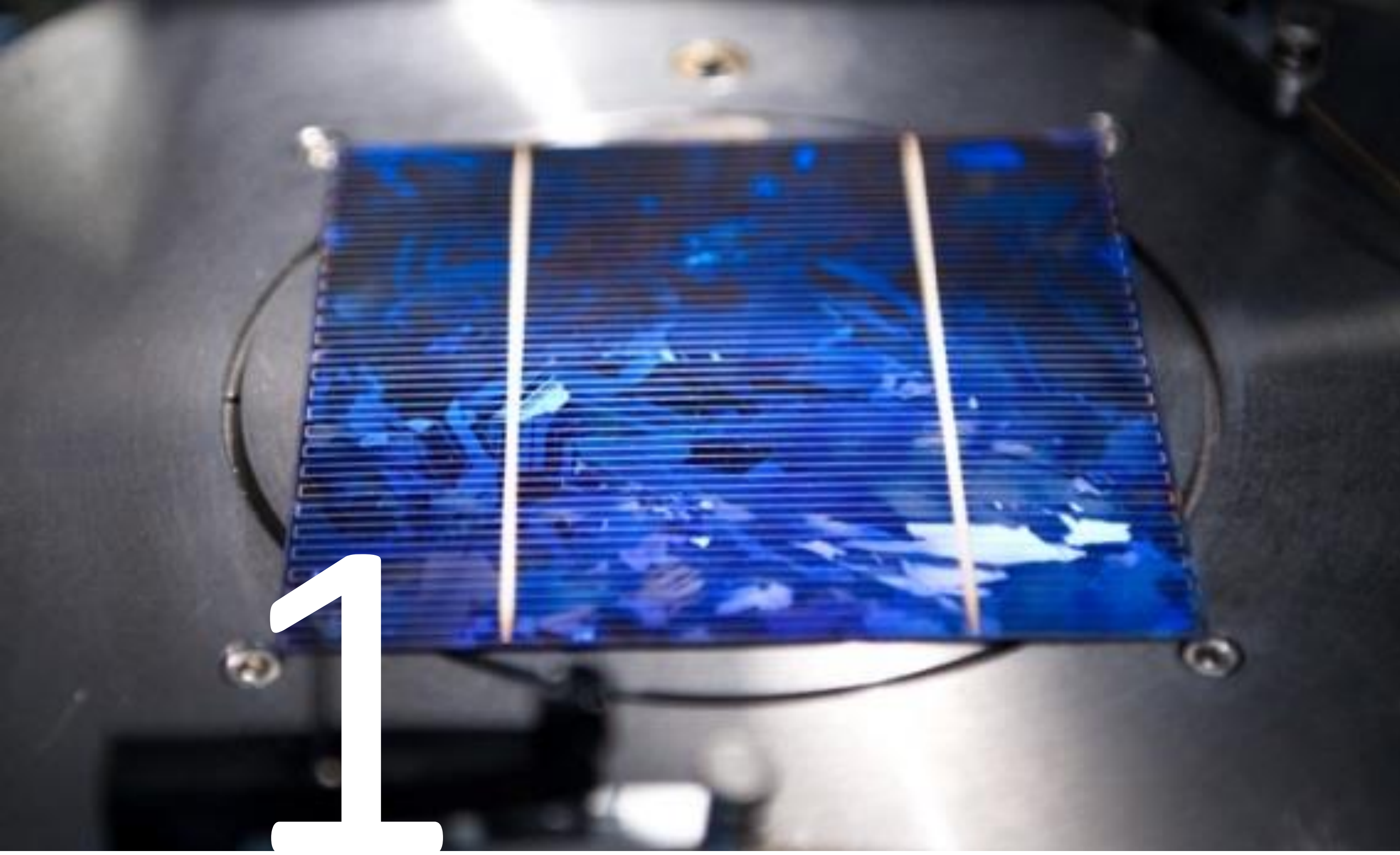
Survey Method

Key data for this publication were drawn mostly from national survey reports and information summaries, which were supplied by representatives from each of the reporting countries. These national survey reports can be found on the website **www.iea-pvps.org**. Information from the countries outside IEA PVPS are drawn from a variety of sources and, while every attempt is made to ensure their accuracy, confidence in some of these data is somewhat lower than applies to IEA PVPS member countries.

Symbols, Abbreviations and Definitions

Standard ISO symbols and abbreviations are used throughout this report. The electrical generation capacity of PV modules is given in watts (W). This represents the rated power of a PV device under standard test conditions of 1 000 W·m-2 irradiance, 25°C cell junction temperature and solar reference spectrum AM 1.5.

The term PV system includes the photovoltaic modules, inverters and all associated mounting and control components as appropriate. Supply chain refers to the procurement of all required inputs, conversion into finished PV products, distribution and installation of these products for final customers. The value chain looks at how increased customer value can be created across a company's business activities, which can include design, production, marketing, delivery and support functions.



Multicrystalline silicon PV cell, NREL, Flash QE, Pauls Stradin, Brian Egaas and David Young

CHAPTER 1 – PV Technology and Applications

PV Technology

The key components of a photovoltaic power system are various types of photovoltaic cells (sometimes also called solar cells) interconnected and encapsulated to form a **photovoltaic module** (the commercial product), the **mounting structure** for the module or array, the **inverter** (essential for grid-connected systems and required for most off-grid systems), the **storage battery** and **charge controller** (for off-grid systems but also increasingly for grid connected ones).

Cells, Modules and Arrays

Photovoltaic cells represent the smallest unit in a photovoltaic power producing device, typically available in 12,5 cm, 15 cm and up to 20 cm square sizes. In general, cells can be classified as either wafer-based crystalline (single crystal and multicrystalline silicon, compound semi-conductor) thin film or organic. Currently, crystalline silicon technologies account for about 80% of the overall cell production in the IEA PVPS countries. Single crystal silicon (sc-Si) PV cells are formed with the wafers manufactured using a single crystal growth method and have commercial efficiencies between 16% and 24%. Multicrystalline silicon (mc-Si) cells, usually formed with multicrystalline wafers manufactured from a cast solidification process, are becoming increasingly popular as they are less expensive to produce but are marginally less efficient, with average conversion efficiency around 14-17%. Quasi-monocrystalline silicon PV cells, manufactured using similar processes as multicrystalline silicon PV cells, have been gaining recent attention. III-V compound semiconductor PV cells are formed using materials such as GaAs on the Ge substrates and have high conversion efficiencies of 40% and more. Due to their high cost, they are typically used in concentrator PV systems with tracking systems or space applications. Thin film cells are formed by depositing extremely thin layers of photovoltaic semi-conductor materials onto a backing material such as glass, stainless steel or plastic. Module conversion efficiencies reported for thin film PV currently range from 7% (a-Si) to 13% (CIGS) but they are potentially less expensive to manufacture than crystalline cells. The disadvantage of low conversion efficiencies is that larger areas of photovoltaic arrays are required to produce the same amount of electricity. Thin film materials commercially used are amorphous and micromorph silicon (a-Si), cadmium telluride (CdTe), and copper-indium-gallium-diselenide (CIGS). Organic thin film PV cells, using dye or organic semiconductors, have created interest and research, development and demonstration activities are underway.

Further research and development is being carried out to improve the efficiency of all the basic types of cells with laboratory efficiency levels of 25% for single crystal cells, and 20% for thin film technologies being achieved.

Photovoltaic modules are typically rated between 50 W and 300 W with specialized products for building integrated PV systems at even larger sizes. Crystalline silicon modules consist of individual PV cells connected together and encapsulated between a transparent front, usually glass, and a backing material, usually plastic or glass. Thin film modules encapsulate PV cells formed into a single substrate, in a flexible or fixed module, with transparent plastic or glass as the front material. Quality PV modules are typically guaranteed for up to 25 years by manufacturers and are type approved to IEC 61215 Ed. 2, IEC 61646 Ed. 2.0 and IEC 61730 International Standards.

A ***PV array*** consists of a number of modules connected in series (strings), then coupled in parallel to produce the required output power. A wide range of ***mounting structures*** has been developed especially for building integrated PV systems (BIPV), including PV facades, sloped and flat roof mountings, integrated (opaque or semi-transparent) glass-glass modules and 'PV roof tiles'. Single or two-axis ***tracking systems*** have recently become more and more attractive, particularly for PV utilization in countries with a high share of direct irradiation. By using such systems, the energy yield can typically be increased by 25-35% for single axis trackers and 35-45% for double axis trackers compared with fixed systems.

Grid-connected PV Systems

In grid-connected PV-systems, an ***inverter*** is used to convert electricity from direct current (DC) as produced by the PV array to alternating current (AC) that is then supplied to the electricity network. The typical weighted conversion efficiency – often stated as 'European' or 'CEC' efficiency of inverters is in the range of 95% to 97%, with peak efficiencies reaching 98%. Inverters connected directly to the PV array incorporate a Maximum Power Point Tracker (MPPT), which continuously adjusts the load impedance to provide the maximum power from the PV array. One inverter can be used for the whole array or separate inverters may be used for each 'string' of modules. PV modules with integrated inverters, usually referred to as 'AC modules', can be directly connected to the electricity network (where approved by network operators) and play an increasing role in certain markets.

Off-grid PV Systems

For off-grid systems a ***storage battery*** is required to provide energy during low-light periods. Nearly all batteries used for PV systems are of the deep discharge lead-acid type. Other types of batteries (e. g. NiCad, NiMH, LiO) are also suitable and have the advantage that they cannot be over-charged or deep-discharged, but are considerably more expensive. The lifetime of a battery varies depending on the operating regime and conditions but is typically between 5 and 10 years.

A ***charge controller*** (or regulator) is used to maintain the battery at the highest possible state of charge (SOC) and provide the user with the required quantity of electricity while protecting the battery from deep discharge or overcharging. Some charge controllers also have integrated MPP trackers to maximize the PV electricity generated. If there is the requirement for AC electricity, a ***'stand-alone inverter'*** can supply conventional AC appliances.

PV Applications and Market Segments

There are six primary applications for PV power systems starting from small pico systems of some watts to very-large-scale PV plants of hundreds of MW:

Pico PV systems have experienced significant development in the last few years, combining the use of very efficient lights (mostly LEDs) with sophisticated charge controllers and efficient batteries. With a small PV panel of only a few watts essential services can be provided, such as lighting, phone charging and powering a radio or a small computer. Expandable versions of solar pico PV systems have entered the market and enable starting with a small kit and adding extra loads later.

Solar PV mini-grid in Chigubuta, Mozambique

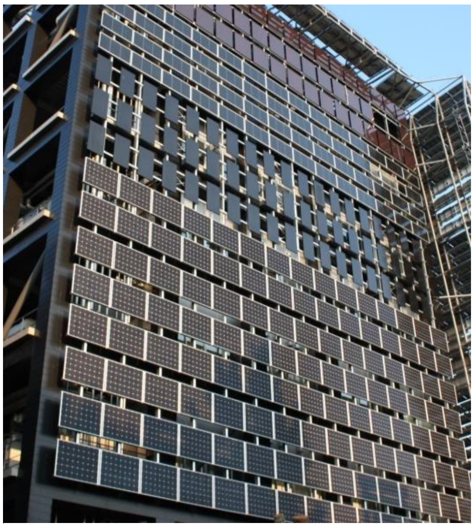
Off-grid domestic systems provide electricity to households and villages that are not connected to the utility electricity network (also referred to as the grid). They provide electricity for lighting, refrigeration and other low power loads, have been installed worldwide and are often the most appropriate technology to meet the energy demands of off-grid communities. Off-grid domestic systems in the reporting countries are typically around 1 to 5 kW in size.

AC coupled PV/Diesel/Batteries Hybrid system implemented at Isona (Lerida), Spain by Granjes Pereto

Generally they offer an economic alternative to extending the electricity distribution network at distances of more than 1 or 2 km from existing power lines. Defining such systems is becoming more difficult where, for example, mini-grids in rural areas are developed by electricity utilities.

Off-grid non-domestic installations were the first commercial application for terrestrial PV systems. They provide power for a wide range of applications, such as telecommunication, water pumping, vaccine refrigeration and navigational aids. These are applications where small amounts of electricity have a high value, thus making PV commercially cost competitive with other small generating sources.

Hybrid systems combine the advantages of PV and diesel hybrid in mini grids. They allow mitigating fuel price increases, deliver operating cost reductions, and offer higher service quality than traditional single-source generation systems. The combining of technologies provides new possibilities. The micro-hybrid system range for use as a reliable and cost-effective power source for telecom base stations continues to develop and expand. The development of small distributed hybrid generation systems for rural electrification to address the needs of remote communities will rely on the impetus given by institutions in charge of providing public services to rural customers. Large-scale hybrids can be used for large cities powered today by diesel generators.



BIPV System in Japan, Courtesy of RTS Corporation

Väla Gard, winner of the Svensk Solenergi's price « The System of the Year ». Courtesy of Skanska Sverige AB

Grid-connected distributed PV systems are installed to provide power to a grid-connected customer or directly to the electricity network (specifically where that part of the electricity network 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. Size is not a determining feature – while a 1 MW PV system on a roof-top may be large by PV standards, this is not the case for other forms of distributed generation.

Grid-connected centralized systems perform the functions of centralized power stations. 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 network other than the supply of bulk power. These systems are typically ground-mounted and functioning independently of any nearby development.

2 MW Utility-scale PV in Yushu, Qinghai Province, China, Courtesy of Lu Fang

Industrial Rooftop PV Installation in Brussels, Belgium, AQUIRIS Water Treatment Center.

CHAPTER 2 – Market Development Trends

More than twenty years of PV market development has seen the deployment of close to 100 GW of PV systems all over the world. However the diversity of PV markets calls for an in-depth look at the way PV developed in all major markets, in order to better understand the drivers of this phenomenal development.

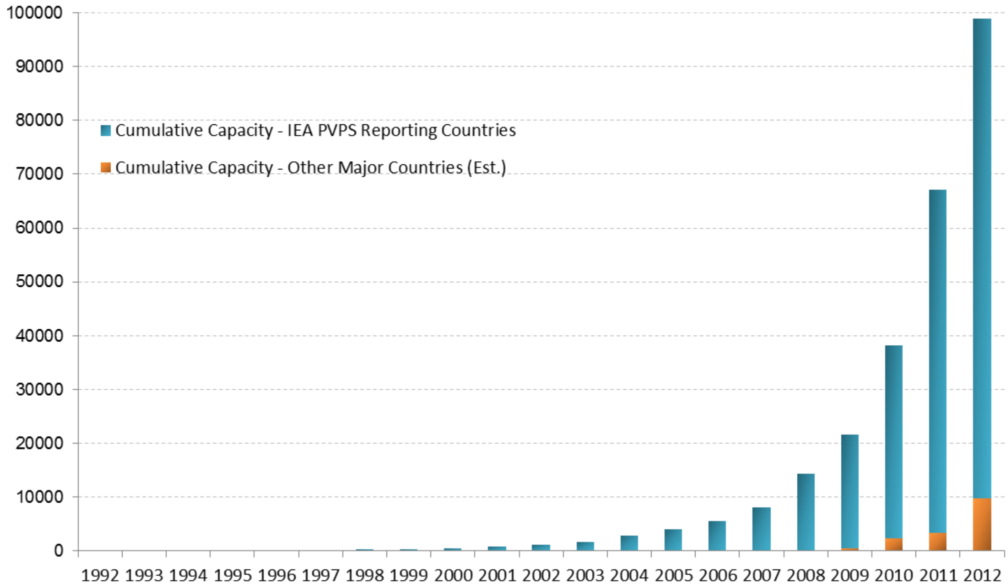
Methodology

This report counts all installations, both grid-connected and off-grid installations. By convention, the numbers reported refer to the nominal power of PV systems installed. These are expressed in W (or Wp). Some countries, such as Spain, are reporting the power output of the PV inverter (the device converting DC power from the PV system into AC electricity compatible with standard electricity networks). The difference between the standard DC Power (in Wp) and the AC power can range from as little as 5% (conversion losses) to as much as 30% (for instance some grid regulations in Germany limit output to as little as 70% of the peak power from the PV system). Conversion of AC data has been made for Spain, in order to calculate the most precise installation numbers every year. Global totals should be considered as indications rather than exact statistics.

The Global Installed Capacity

The IEA PVPS countries represented 89,3 GW of cumulative PV installations altogether, mostly grid-connected, at the end of 2012. Eight countries that are not part of the IEA PVPS Programme represent 7 additional GW, mostly in Europe: Czech Republic with 2,1 GW installed, Greece with 1,5 GW, and below the GW mark, Bulgaria, Slovakia and Ukraine. In Asia Thailand and Taiwan represent 600 MW together. Next to these countries, India has installed more than 1,1 GW.

Figure 1: Evolution of Cumulative PV Capacity (MW)



In other European countries, 285 MW have been installed so far and outside Europe, the European Photovoltaic Industry Association believes that an additional 2,7 GW of PV systems have been installed in the last twelve years.

While other countries around the world have reached various PV installations levels, the total of these remains hard to quantify with certainty. Some could argue the 100 GW mark worldwide has been passed, but evidence remains limited. At present it seems that 96,6 GW represents the minimum installed by end 2012 with a firm level of certainty. Adding 2,7 GW of additional capacities spread all over the world would increase the total to 99,3 GW, below the 100 GW mark.

The Market Evolution

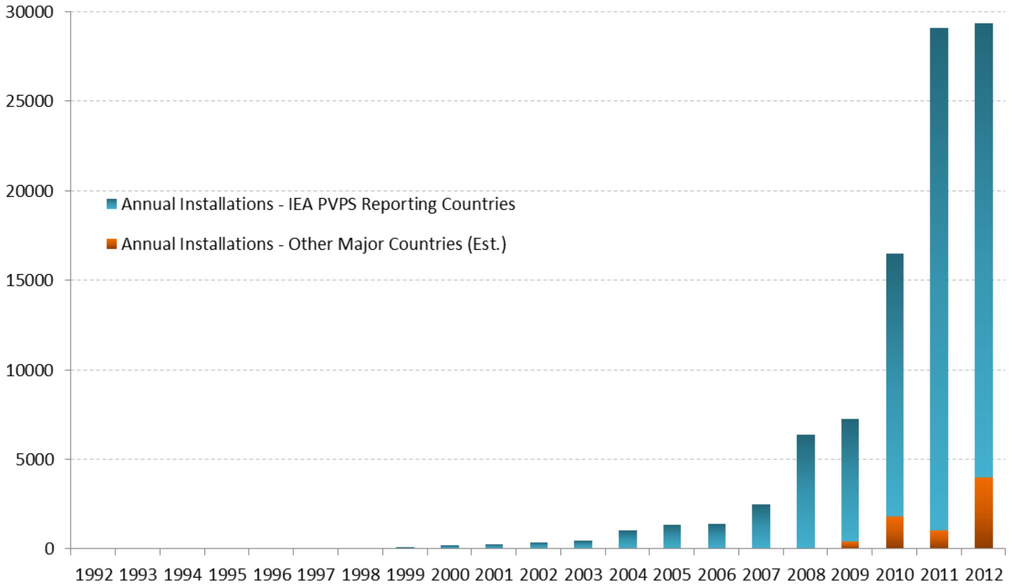
The countries of the IEA PVPS Programme have installed 25,3 GW of PV, with a minimum worldwide installed capacity in 2012 totaling 28,6 GW. While they are hard to track with a high level of certainty, installations in non-IEA PVPS countries are pushing the installed capacity above 28 GW in 2012. While some new countries have reportedly installed some PV, installations numbers for 2012 have stabilized in 2012 compared to 2011. The European Photovoltaic Industry Association believes that an additional 600 MW have been installed in Asia, Africa, the Middle-East and America. This would put the world market for PV in 2012 to 29,3 GW.

Germany installed 7,6 GW, after two years at similar levels of PV installations. This occurred in the context of reduced feed-in tariffs, pushing self-consumption as a natural driver of PV development in this country where the total installed PV capacity is now more than 32 GW. Behind the German leader, **Italy** is second with 3,6 GW installed in 2012, down from the tremendous and unsustainable 9,3 GW the previous year. Now that the financial cap set by the Italian authorities as a limit for the cost to be borne by electricity consumers has been passed, the future of Italian PV development will have to rely more on self-consumption than feed-in tariffs. The 16,4 GW installed in Italy will produce at least 6,9% of the electricity demand of the country in 2013, an undisputed world record. **China** reached third place, with 3,5 GW installed: This performance is in line with the ambitions of the Chinese authorities to continue developing its internal PV market, pushing for 35 GW by the year 2015, starting now at 7 GW.

Close to the third place, the **USA** reached the 3,3 GW mark and now has about 7,2 GW of installed capacity.

The fifth place goes to **Japan**, with 1,7 GW installed. This performance puts the total installed capacity in this country at 6,6 GW. Together, these countries represent 70% of all installations recorded in 2012 and slightly more in terms of installed capacity.

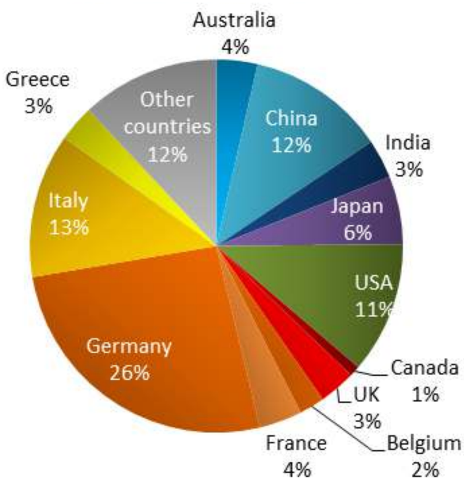
Figure 2: Evolution of Annual PV Installations (MW)



The following five places go to **France** (1,1 GW), **Australia** (1 GW), **India** (just below 1,0 GW), the **UK** (0,9 GW) and **Greece** (0,9 GW). Together these 10 countries cover 88% of the 2012 world market.

Smaller size countries have performed quite significantly and raised their total installed capacity above the GW mark: **Belgium** installed 600 MW and has now reached 2,7 GW

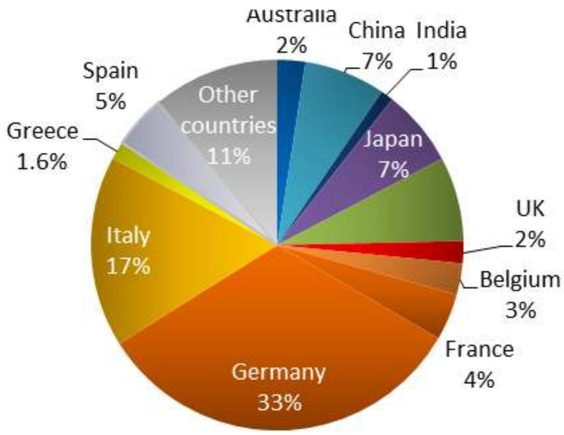
Figure 3: The Global PV Market in 2012



while **Korea** has passed the GW mark with a more vigorous market than in the last few years. Some countries that grew dramatically over recent years have now stalled or experienced very small additions: **Spain** now totals 4,7 GW of PV systems (4,44 GW reported by the authorities[1]) followed by the Czech Republic at 2,1 GW.

In Europe, net-metering systems allowed the market to grow quickly in **Denmark** (310 MW added) and the **Netherlands** (195 MW reported), with significant additions in **Switzerland** (226 MW) and **Austria** (175 MW).

Figure 4: Cumulative Capacities in 2012



In Asia, next to China, Japan and Korea, **Thailand** is progressing fast with preliminary data showing around 173 MW installed in 2012. **Malaysia** installed 27 MW for the first year of its feed-in tariff system. **Taiwan** installed 104 MW in a growing market.

[1] Spain reports PV installations in AC while most countries report DC power.

In America, preliminary data for **Canada** shows the installation of 268 MW while the appetite for PV in Latin and Central America hasn't transformed into a real market yet. Several GW of PV plants have been validated in Chile, but except in Peru with some 50 MW and **Mexico** with 15 MW, the real PV development of grid-connected PV plants hasn't started yet in the region.

In the Middle East, **Israel** progressed rapidly, with close to 0,75% of its electricity already coming from PV while the PV installations in **Turkey** have started more slowly with around 2 MW installed in 2012.

A Fast Changing Market

Table 1: Evolution of Top 10 Markets

	2010	2011	2012
1	*Germany*	*Italy*	*Germany*
2	*Italy*	*Germany*	*Italy*
3	*Czech Rep.*	*China*	*China*
4	*Japan*	*USA*	*USA*
5	*USA*	*France*	*Japan*
6	*France*	*Japan*	*France*
7	*China*	*Belgium*	*Australia*
8	*Belgium*	*UK*	*India*
9	*Spain*	*Australia*	*UK*
10	*Australia*	*Greece*	*Greece*
	Market level to access the top 10		
	383 MW	*425 MW*	*912 MW*

While large markets such as Germany or Italy have exchanged the two first places, some small countries with impressive and unsustainable market evolutions appear in the Top 10: The Czech Republic experienced a dramatic market uptake in 2010, immediately followed by a collapse; Belgium and Greece installed hundreds of MW several years in a row. 2012 starts to show a more reasonable market split, with China, Japan and the US climbing up to the first places, while India, UK and Australia confirm their market potential. The market level necessary to enter this top 10 grew quite fast, with close to 1 GW necessary in 2012.

Largest Additions Ever

While 2012 saw Germany installing once again more than 7 GW, Italy still tops the list with 9,3 GW. Countries that installed at least 1 GW of PV system in one year are numerous and their number is growing every year. The table 2 shows the emergence of non-European countries in this list.

Table 2: Top 20 Largest Additions of Capacities in MW

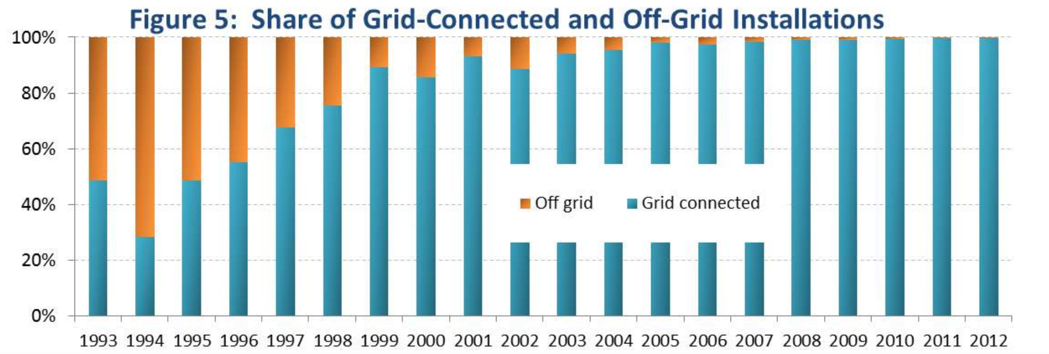
		Year	MW
1	*Italy*	2011	9305
2	*Germany*	2012	7604
3	*Germany*	2011	7485
4	*Germany*	2010	7413
5	*Germany*	2009	3806
6	*Italy*	2012	3647
7	*China*	2012	3500
8	*USA*	2012	3362
9	*Spain*	2008	2896
10	*China*	2011	2500
11	*Italy*	2010	2322
12	*Germany*	2008	1958
13	*USA*	2011	1867
14	*France*	2011	1759
15	*Japan*	2012	1718
16	*Japan*	2011	1296
17	*Germany*	2007	1277
18	*France*	2012	1079
19	*Australia*	2012	1038
20	*Belgium*	2011	1002

Off-grid Market Development

The off-grid market can hardly be compared to the grid connected market: The rapid deployment of grid-connected PV dwarfed the off-grid market as figure 5 clearly shows.

Nevertheless, off-grid applications are developing more rapidly in several countries than in the past and some targeted support has been implemented.

In Australia 16 MW of off-grid systems have been installed in 2012. In China, some 40 MW of off-grid applications have been installed in 2012, with an unknown percentage of hybrid systems. It can be considered that most industrial applications and rural electrification systems are most probably hybrid. This would raise the number of hybrid systems installed in China to about 30 MW, against 10 MW of pure off-grid PV applications.



In most European countries, the off-grid market remains a very small one, mainly for remote sites, leisure and communication devices that deliver electricity for specific uses. Some mountain sites are equipped with PV as an alternative to bringing fuel to remote, hardly accessible places. However this market remains quite small, with at most some MW installed per year per country.

In Japan, some MW have been installed, bringing the installed capacity above 100 MW, mainly in the non-domestic segment.

In some countries, off-grid systems with back-up (either diesel generators or chemical batteries) represent an alternative to bringing the grid in remote places. This trend is specific to countries that have enough solar resource throughout the year to make a PV system viable. In most developed countries in Europe, Asia or America, this trend hasn't been seen and the future development of off-grid applications will most probably be seen first on remote islands. The case of Greece is rather interesting in Europe, with numerous islands not connected to the mainland grid that have installed dozens of MW of PV systems in the previous year. These systems, providing electricity to some thousands of customers will require rapid adaptation of the management of these mini-grids in order to cope with high penetrations of PV. The French islands in the Caribbean Sea and the Indian Ocean have already imposed specific grid codes to PV system owners: PV production must be forecasted and announced in order to better plan grid management. As an example, the island of La Reunion operated more than 150 MW of PV at the end of 2012 for a total population of 840 000. While this represents roughly 50% of the penetration of PV in Germany, the capacity of the grid on a small island to absorb fast production and consumption changes is much more challenging.

Outside the IEA PVPS network, Bangladesh installed an impressive amount of off-grid SHS systems in recent years. Two million systems were operational by the end of 2012 with an average size of 60 W. This represents a total

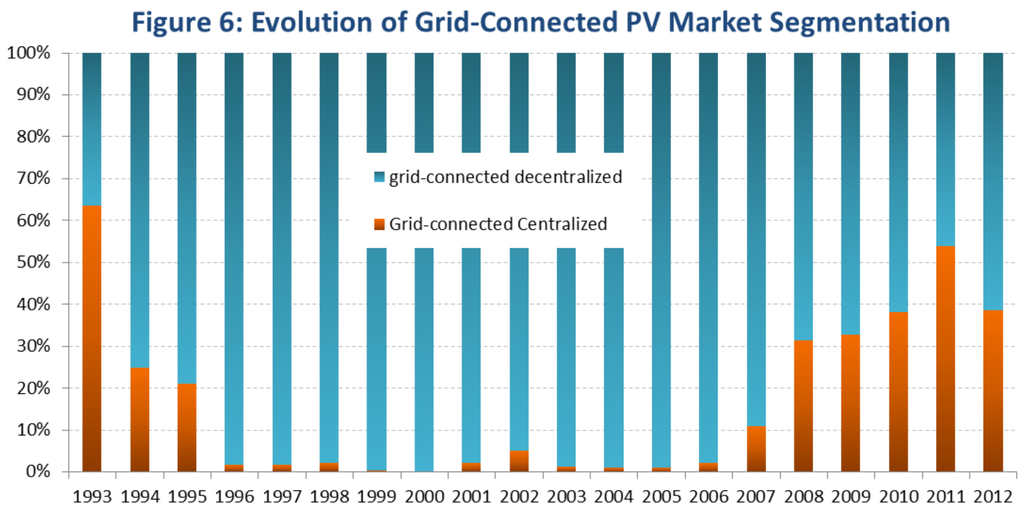


Table 3: Evolution of Annual Installations and Total Capacities per Region 2010/2012

	Annual Installations (MW)			Total Capacities (MW)		
	2010	2011	2012	2010	2011	2012
America	1082	2151	3745	2334	4505	8251
Europe	13379	22132	17268	30109	52235	69634
Middle East & Africa	46	120	349	70	190	545
Asia Pacific	2002	4681	7971	5652	10333	18735

installed capacity of around 120 MW, quite significant in the South-East Asia region.

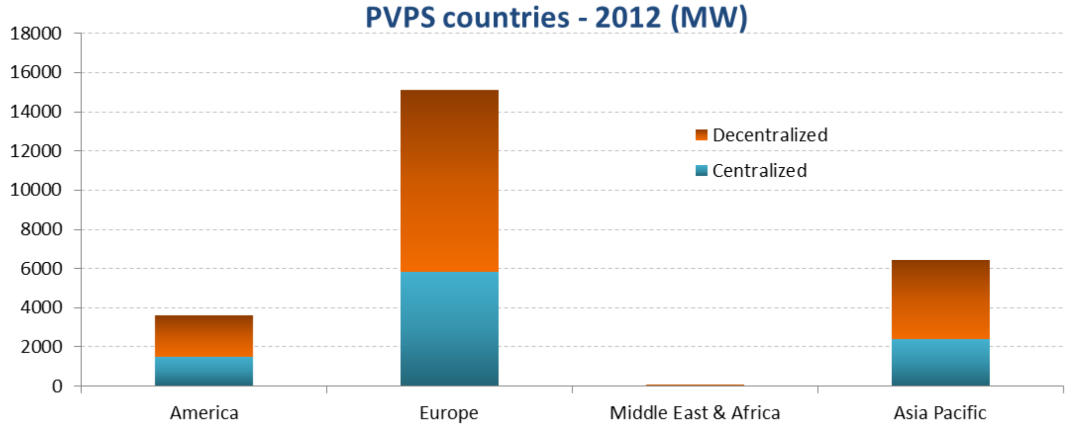
India has foreseen up to 2 GW of off-grid installations by 2017, including 20 million of solar lights in its National Solar Mission. These impressive numbers show how PV now represents a competitive alternative to providing electricity in areas where traditional grids were not deployed. In the same way as mobile phones are connecting people without the traditional lines, PV is perceived as a way to provide electricity without building complex and costly grids first. The challenge of providing electricity for lighting, communication, including access to the Internet, will see the progress of PV as one of the most reliable and promising source of electricity in developing countries in the coming years.

PV Development per Region and Segment

The growth of grid-connected PV markets has dwarfed the off-grid market for more than ten years as Figure 5 above clearly showed. The evolution of grid-connected PV towards a balanced segmentation between centralized and decentralized PV has reversed course in 2012: decentralized PV has evolved faster with several countries deciding to discontinue the support for utility-scale PV in Europe. This evolution has different causes: environmental concerns about the use of agricultural land, difficulties of reaching competitiveness with wholesale electricity prices in this segment, grid connection issues for instance. This doesn't imply the end of development in the utility-scale segment in these countries but at least a rebalancing towards self-consumption driven business models.

The same pattern between decentralized and centralized PV is visible in the Asia Pacific region and in the America's. However, this could change in the coming years, with the arrival of more developing countries that could focus on pure electricity generation rather than self-consumption driven business models. The availability of cheap capital for financing PV installations could reinforce this evolution.

Figure 7: Centralized & Decentralized PV installations by Region in PVPS countries - 2012 (MW)



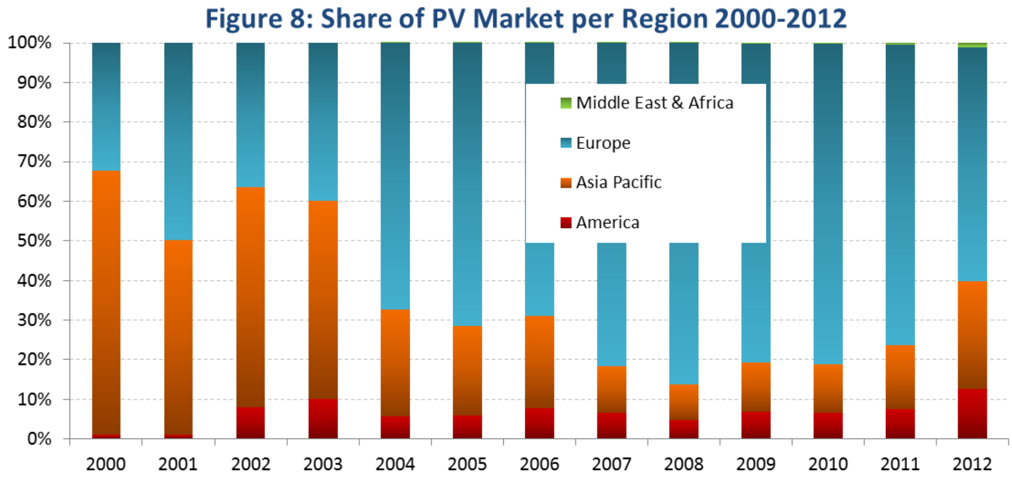
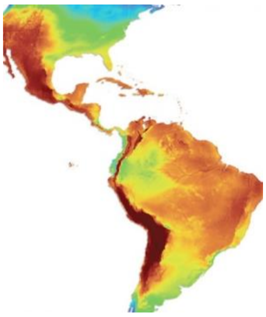


Figure 8 illustrates the evolution of the share of grid-connected PV installations per region from 2000 to 2012: While Asia started to dominate the market in the early 2000's, the start of FiT-based incentives in Europe and in particular in Germany caused a major market uptake in Europe. While the market size grew from around 2 MW in 2000 to close to half a GW MW in 2003, the market started to grew very fast, thanks to European markets in 2004. From around 1 GW in 2004, the market reached close to 2,5 GW in 2007. In 2008, Spain fueled market development while Europe achieved more than 80% of the global market, a performance repeated until 2010.

While Europe still represents a major part of all installations globally, the share of Asia and America started to grow rapidly in 2012. This evolution is quite visible from 2010 to 2012, with the share of the Asia and Pacific region growing from 17% to almost 30%, whereas the European share of the PV market went down from 82% to 59% in two years. Many expect that Europe will lead its leadership in 2013, with Asia possibly installing as much or even more PV systems as Europe.

Finally, for the first time in 2012, the share of the PV market in the Middle East and in Africa becomes visible. These two regions of the World haven't yet stepped in PV development but many countries have initiated PV programmes and could appear on the map in the two coming years.

600 kW PV, Dongao Island, Guangdong, China, Courtesy of Lu Fang



The Americas

The Americas represented in 2012 3,7 GW of installations and a total cumulative capacity of 8,3 GW. If most of these capacities are located in the USA, and in general in North America, several countries are showing signs of interest for PV and the market could develop fast in the coming years in the south of the continent.

Canada

At the end of 2012, the installed capacity of PV systems in Canada reached 766 MW, out of which 268 MW were installed in 2012. Decentralized rooftop applications amounted to 87 MW installed in 2012 while large-scale centralized PV systems reached 181 MW the same year. The market was dominated by grid-connected systems while off-grid applications were not measured in 2012, but estimated around 1% as in 2011.
Prior to 2008, PV was serving mainly the off-grid market in Canada. Then the FiT programme created a significant market development in the province of Ontario. In 2012, in order to review the programme, province authorities suspended project approvals for a year. Despite this, installations in 2012 slightly diminished at 208 MW, down from 277 MW in 2011 and up from 187 MW in 2010. These installations are still largely concentrated in the province of Ontario.

Ontario's Feed-in Tariff Program

This FiT programme is North America's first comprehensive guaranteed pricing structure for electricity production from RES. It aims at targeting 10,7 GW of non-hydro RES sources by 2018 in the province under its current Long Term Energy Plan. The first part targets generators above 10 kW (the "FiT Programme") while the second part focuses on systems below that limit ("MicroFiT programme"). PV systems can be granted the FiT for a period of 20 years. A particularity of this programme is the imposition of a 60% domestic (Ontario) content policy: This regulation was challenged in front of the WTO that ruled against Ontario in 2012 with a possible appeal in 2013.

In 2012, the FiT levels were reviewed and tariffs were reduced by up to 31% to follow the PV system costs decrease.
PV remains a marginal source of electricity in other provinces, although the province of Alberta could be the second to step into PV development.

Mexico

14,7 MW of PV systems were installed in Mexico in 2012, increasing the total capacity in the country to 51,8 MW. The lack of nationwide support explains why Mexico hasn't seen a real market take-off, despite excellent solar resource. The possibility to achieve accelerated depreciation for PV systems exists at the national level and some local incentives such as in Mexico City could help PV to develop locally.

A net-metering scheme (Medición Neta) exists for PV systems below 500 kW mainly in the residential and commercial segments. The price of PV electricity for households with high electricity consumption (DAC) is already attractive from an economic point of view since they pay more than twice the price of standard consumers. At the end of 2012, around 1 600 customers were using this scheme.

Since 2012, this net-metering is also available for multi-family housing, with pre-arranged shares.

A virtual net-metering system exists for large installations, with the possibility to net electricity consumption and production at distant sites.

In December 2012, the National Fund for Energy Savings announced the start of a new financing scheme for PV systems for DAC consumers: 5 year loans with low interest rates can be used to finance PV systems.

Rural electrification is supported through a Solar Villages program.

Large power plants have been announced that could increase the PV market to several hundreds of MW a year. Some expect 100 to 200 MW in 2013, which would be in line with the government target of 2 GW in 2025.

USA

Total PV capacity in the US surpassed 7,2 GW at the end of 2012 with 3 326 MW added during that year. 1,3 GW was installed in the last quarter alone. The total installed solar power capacity in the US is now 7 272 MW – or more than 300 000 installations.

The US PV market has been driven by tax credits granted by the federal US government for some years with net-metering offered in some states as a complementary measure.

Splitting ranks by installation type, California is still top in the residential segment but came second in annual utility-scale installations in 2012, behind Arizona - though the US Solar Energy Industry Association (SEIA) predicts it will overtake Arizona in this segment this year.

In terms of annual installations, California still ranked as the top state in 2012 with 1 045 MW installed, followed by Arizona, New Jersey, Nevada and North Carolina. The top five for cumulative solar power capacity installed in 2012 were California, Arizona, New Jersey, Nevada and Colorado.

Utility-scale installations totaled 784 MW in 2011 and 1 803 MW in 2012 with 10,5 GW in the pipeline according to power purchase agreements – 3,1 GW of which is already under construction. The utility procurement will most probably slow down, as utilities reach and exceed renewable energy obligations.

Renting rooftop solar systems has taken off and is expected to continue to be popular; making up 68% of the residential US solar market in 2012, with residential system prices dropping 14% between the 2011 and 2012.

State rebates have played a significant role in accelerating the deployment of solar installations in the United States by reducing the upfront cost of owning a system. These programmes vary widely by incentive level, annual budget, installer and equipment requirements, installation results, and other criteria. They are active in California and a dozen other states with various results.

Tax credits help offset the expense of purchasing and installing solar energy systems by directly reducing the project owner's tax liability and can play an important role in promoting solar, especially in states where direct incentives such as rebates and grants are not available. State tax credits vary widely by eligibility criteria, incentive level, annual budget, installer and equipment requirements, and other criteria. They are active in Arizona, North Carolina, Hawaii, and several other states.

Net-metering has developed as an alternative way of supporting the deployment of PV and is implemented in more than 40 states. But the debate has started about the consequences of net-metering policies for utilities and some changes could appear in 2013 and after.

RPS policies have been set up in several states with a solar provision. The quota varies from one state to another, ranging from 0,2% of solar by 2018 in North Carolina to 4,1% in New Jersey by 2027. In some cases, solar quotas are not specified but distributed generation is targeted: This is the case for Arizona for instance.

Third party PPAs are allowed in more than 20 states.

PACE programmes have been introduced in more than 20 states as well; PACE (Property Assessed Clean Energy) is a means of financing renewable energy systems and energy efficiency measures. It also allows avoiding significant upfront investments and eases the inclusion of the PV system cost in case of property sale.

Argentina

The Government has set-up renewable energy targets for 2016 of 3 GW. This includes 300 MW for solar PV systems. However, so far the development was quite small, with only 6 MW installed in the country. Government subsidizes PV through public-private partnerships. Public funding has been estimated to 35 Million ARS last year (all solar technologies together).

Two main segments are considered: Social housing and PV in the built environment. In parallel, large PV systems are being considered. Plans for PV development have been announced starting mid 2012 with at least one 50 MW plant. Some large plants could get funding and PPAs in order to develop this segment. At least one plant of 180 MW has been announced in the province of San Luis.

Brazil

With around 45 MW installed at the end of 2012, mostly off-grid, PV remains a marginal source of electricity in the country.

New regulations have been approved including tax breaks on PV systems up to 30 MW in size. This could develop the market in the segment of large PV plants. Energy regulator ANEEL has received applications for PV plants totalling 1 GW, with capacity in between 1 and 30 MW. But larger projects have been investigated by developers in the country. Even if all of these projects won't be realized in the end, they show an interest for PV as a source of clean electricity in Brazil.

Some projects aim at selling electricity on the regional electricity market to provide electricity to industrial companies.

In addition, a new net-metering system has been put in place for systems up to 1 MW and will be active in 2013. This system allows compensating production and consumption over a period of 36 months. This compensation will be organized by rate periods (peak PV electricity can compensate for peak consumption and in the same way for off-peak production). Net-metering is allowed between distant production and consumption sites if they belong to the same user and take place in the same grid area.

But PV hasn't yet reached competitiveness with retail electricity prices: Beginning 2013, prices were reduced by 18 to 26% for end consumers, which will push away grid parity in the country.

Some states are pushing harder (Amazonas for instance) but mainly for small scale PV plants off-grid so far.

Finally, Brazil will open energy auctions to PV for the first time in 2013. Some expect PV developers to apply to several GW of PV projects.

This could lead to a real market start in 2013-2014 with hundreds of MW installed each year.

Chile

Chile experienced a boom in PV projects announcements in 2012 that hasn't yet materialized in real installation numbers. 3,6 MW were installed by the end of 2012, but much more are expected in the coming years. The country is divided into 4 independent electricity grids and most projects are concentrated in the northern one where all mining sites are located. Lack of power generation in the region of the Atacama Desert is pushing electricity prices quite high.

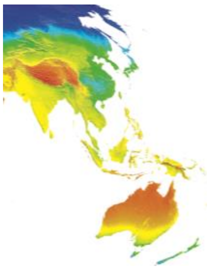
More than 2,4 GW of large PV projects were approved at the end of 2012 and more than 1,5 GW received an environmental permit. Nevertheless, huge uncertainties remain about most projects' timelines.

Renewable energy quotas oblige utilities to buy at least 5% of their annual traded electricity from RES but no provision for PV exists as such.

Finally, in March 2012 a net-billing regulation was introduced for systems up to 100 kW: PV electricity in excess can be valued at a price lower than the retail price (depending on the conditions, this could be the equivalent of the market price). So far this law hasn't entered into force and is thus not yet applicable.

Other Countries

Several other countries in Central and Latin America have put support schemes in place for PV electricity. **Ecuador** is becoming a small but promising market with FiT legislation (0,40 USD/kWh – 15 years) in place and some ground mounted projects (up to 30 MW) announced as being built in 2013. **Uruguay** announced the intention to launch a call for tender for 200 MW of PV with a PPA in early 2013 at the low 90 USD/MWh rate. The net-metering system launched in 2010 failed to develop the market so far. In **Peru** a double 20 MW plant that has been operational since end 2012 was inaugurated begin 2013. Other plants are foreseen until 2014. This comes from an 80 MW blind bidding process launched in 2010 with a ceiling tariff fixed at 0,269 USD/kWh. The **Dominican Republic** is validating a 100 MW project to be completed in 2014. Next to this, a net-metering system and tax breaks are supposed to develop the small-scale residential and commercial markets. French overseas departments have seen an important increase of PV penetration in the last years, with 34 MW in French Guyana, 60 MW in Martinique and 64 MW in Guadeloupe and some smaller numbers in Saint Martin. They represent so far the largest density of PV installations in the Caribbean region.



Asia – Pacific

The Asia Pacific region installed close to 8 GW in 2012 and more than 18,7 GW are producing PV electricity. This region experienced the fastest market development in 2012 and will most probably continue in the same way.

Australia

After having installed 806 MW in 2011, Australia continued in 2012 with 1 038 MW installed. The country has more than 2,4 GW of PV systems installed and commissioned, mainly in the residential rooftops segment, with grid-connected applications. Only a mere 21,5 MW can be considered as large scale centralized power plants while off-grid applications amounted in 2012 to 10 MW in the domestic sector and 6 MW for non-domestic applications.

Market Drivers

Australian Government support programmes impacted significantly on the PV market in 2011 and 2012.The 45 000 GWh Renewable Energy Target (RET) (a quota-RPS system) consists of two parts – the Large-scale Renewable Energy Target (LRET) of 41 000 GWh by 2020 and the Small-scale Renewable Energy Scheme (SRES). Liable entities need to meet obligations under both the SRES and LRET by acquiring and surrendering renewable energy certificates created from both large and small-scale renewable energy technologies. The SRES covers small generation units (small-scale PV, small wind turbines and micro hydroelectric systems) and solar water heaters, creating small-scale technology certificates (STCs). Certificates are granted during 15 years. The number of certificates granted will be equal to those produced by other technologies from January 2013 onwards, down from a factor 5 multiplier in 2009.

Large scale PV benefited from an auction (ACT programme) in January 2012 for up to 40 MW. Successful proponents have been announced in 2013. The Solar Flagship Programme announced a successful project with 150 MW of large-scale PV planned. In addition, numerous solar cities programmes are offering various incentives that are complementing national programmes.

State Based FiTs

The market take-off in Australia accelerated with the emergence of feed-in tariffs programmes in several states to complement the national programmes. Some continue to be active in 2013.

Self-consumption

No promotion of self-consumption as such exists in Australia. However, low or zero Feed-in Tariffs for new connections automatically favor self-consumption.

Conclusion

With rapidly evolving support schemes, at national and state level, the Australian market evolved quite rapidly over the previous three years. A combination of good solar irradiation, rising electricity prices and the difficulty bringing the grid to remote areas has pushed the PV market ahead.

China

With 7 GW installed and 3,5 GW installed in 2012 alone, the Chinese PV market has started to grow fast but slower than expected, even by Chinese authorities.

Since 2008, utility-scale PV has become the main segment developing in China. However, more recently rooftop PV has received some interest and starts to develop, in both BAPV and BIPV segments.

Several schemes are incentivizing the development of PV in China. They aim at developing utility-scale PV through adequate schemes, rooftop PV in city areas and micro-grids and off-grid applications in un-electrified areas of the country. The following schemes were in place in 2012:

- A feed-in tariff scheme for utility-scale PV that is financed by a renewable energy surcharge for electricity consumers.
- A capital subsidy for PV on buildings (the PV Building Project), financed through a special fund for renewable energy.
- The so-called "Golden Sun Program" fund that also aims to develop PV on buildings and off-grid applications. The 4th phase started in 2012 with 1 709 MW of projects receiving the capital subsidy.
- And from November 2012, 2 830 MW were also selected for the two last subsidy programmes.
- In total, the existing programmes are covering up to 10,5 GW of projects already installed or approved for future installations.

From December 2012, FiT levels will be adjusted according to the solar resources and a self-consumption subsidy has been introduced. In case of self-consumption, the excess electricity can be acquired by the grid operator and a bonus can be paid on the top of the wholesale electricity price. Additionally, it is expected that the FiT will progressively take over the subsidy programmes while self-consumption driven applications will be more incentivized than utility-scale ones.

The market is mostly concentrated in the grid connected systems, with only 40 MW of off-grid applications developed in 2012. On the other hand, utility-scale PV developed in desert areas of China, with around 2 GW installed in 2012. In total, distributed applications now represent more than 50% of the total with 3 775 MW installed.

In 2012, some important milestones were announced:

- The promotion of self-consumption for families and public buildings has been announced.
- The increased target for solar (PV and CSP) up to 21 GW in 2015 initially and then in December up to 35 GW.
- Additional regulations aiming at promoting or framing the development of distributed generation.

Grid connection, especially for large scale PV became more difficult in 2012, due to inadequate grid regulations and management in some regions. This has led to curtailment issues already in 2012 and will be the key to further PV development. In addition, PV requires adequate funding solutions that will require also more transparency from the PV sector with regard to quality. Solutions could be found through third party financing and the use of adequate insurance in order to better the perception of financing parties and lower the cost of capital and therefore the cost of PV electricity.

Comments

China has the potential to very quickly become the number one PV market in the world. Adequate policies are being put in place progressively and will allow the market to continue growing fast.

Japan

Total annual installed capacity of PV systems reached 1 718 MW in 2012 in Japan, approximately 33% increase from that of 2011 with 1 296 MW. The total cumulative installed capacity of PV systems in Japan in 2012 reached 6 631 MW.

In the first half of 2012, the PV market development was led by a subsidy programme for residential PV systems and a programme to purchase grid-injected PV power from systems below 500 kW at a preferential price. With the start of the Feed-in Tariff (FiT) programme in July 2012, the market for public, industrial application and utility-scale PV systems grew fast. The breakdown of PV systems installed in 2012 is 3,3 MW for off-grid domestic application, 2,8 MW for off-grid non-domestic application and 1 712 MW for grid-connected distributed application.

2012 has seen the development of large-scale centralized PV systems for the first time, a sign that the PV market in Japan is developing outside the traditional rooftop market.

Investment Subsidy

The subsidy program, restarted in 2009, aims to promote the dissemination of high-efficiency (depending on the technology, efficiency must be above in between 8,5% and 16%) and low-price PV systems below 10 kW. Therefore, two levels of investment grants (30 000 and 35 000 JPY/kW) are set depending on the system price for priority allocation. A specific certification scheme has to be met. This led to around 200 000 projects and an installed capacity of 911 MW (down from 1 023 MW in 2011).

Feed-in Tariff

On July 1st 2012, the existing scheme that allowed purchasing excess PV production was replaced by a new Feed-in tariff scheme. Its cost is shared among electricity consumers with some exceptions from electricity-intensive industries.

Systems above 10 kW will receive 42 JPY/kWh (40 JPY/kWh plus tax not to be repaid) during a period of 20 years for the gross electricity produced by the PV system. Systems below 10 kW with self-consumption receive per kWh 42 JPY (tax included but this one has to be repaid) for the excess electricity injected into the grid. In 2012, this scheme led to the approval of 4,7 GW of future installations: out of which 847 MW (close to 194 000 systems) below 10 kW, 1 681 MW between 10 kW and 1 MW and 2,18 GW above 1 MW (742 systems). With little doubt, this will be translated mainly in the 2013 market numbers.

Other Support Schemes

Other schemes exist in Japan, with various aims: The “project supporting acceleration of introduction of new and renewable energy” from the METI, has been launched in 2011 and supports among other technologies, PV in the regions damaged by the great eastern Japan earthquake of 2011. Another subsidy comes from the Ministry of Environment and supports climate change enabling technologies for local authorities’ facilities, industrial facilities, schools, local communities and cities. Such projects are also promoting the use of local storage (batteries) to favor the development of renewable sources of energy. Other schemes can be found as well, showing how Japan is seriously considering the development of PV as an alternative source of electricity for the future.

It is interesting to note that Japan was at the forefront of PV development and lost its place when PV started to develop quickly in Germany. The combination of falling system prices, political and public awareness about PV after the great earthquake of 2011 and smart policies has contributed and will continue to contribute to Japan’s PV market development in the coming years.

Republic of Korea

Since the record-breaking year of 2008, that saw 276 MW of PV installations, the PV market became stagnant in Korea during three years with about 156 MW installed in 2011. This was mainly due to the limited FiT scheme which played initially an important role in the PV market expansion. However, in 2012 230 MW were installed thanks mainly to the newly introduced RPS scheme (with PV requirements).

At the end of 2012, the total installed capacity was about 959,2 MW, among them the grid-connected centralized system accounted for 77% of the total cumulative installed power. The grid-connected distributed system amounted to 23% of the total cumulative installed PV power. On the other hand the share of off-grid non-domestic and domestic systems has continued to decrease to about 0,6% of total cumulative installed PV power.

The total capacity of 959,2 MW corresponds to 1,17% of total power generation capacity (81 806 GW), while the 230 MW installed in 2012 account for 4,5% of all power generation capacities installed in 2012.

Various incentives have been used to support PV development. In 2008, the “Third Basic Plan for the Promotion of Technological Development, Use, and Diffusion of New and Renewable Energy” based on the “First National Energy Basic Plan” was issued. This plan includes the construction of “One Million Green Homes” and “200 Green Villages” by 2020. Based on this plan, the RPS (Renewable Portfolio Standards) scheme will replace the existing “Feed-in-Tariff” scheme from 2012 onwards. The RPS was launched in 2012 as planed and will be active until 2020.

Home Subsidy Programme (One Million Green Home Program)

This programme was launched in 2004 that merged the existing 100 000 rooftop PV system installation program, and it aims at the construction of one million green homes utilizing PV as well as solar thermal, fuel cells, wind, bio-energy and geothermal until 2020. In general, single-family houses and multi-family houses including apartments can benefit from this program. The Government provides 60% of initial PV system cost for single-family and private multi-family houses, and 100% for public multi-family rent houses. The maximum PV capacity allowed for a household is 3 kW. At the end of 2012, 141 000 households (122 MW of PV capacity) benefited from this program.

RPS Program

The RPS is a mandated requirement that the electricity utility business source a portion of their electricity supplies from renewable energies. In Korea, electricity utility business companies exceeding 500 MW are required to supply total 10% of their electricity from NRE (New and Renewable Energy) sources by 2022, starting from 2% in 2012. Before starting the formal RPS programme from 2012, the Government initiated the RPS demonstration programme for three years from 2009 until 2011. Six Korean electricity generation companies have signed the ‘RPA (Renewable Portfolio Agreement)’ with the Government in order to increase the share of renewable energy electricity generation. The total capacity was fixed to be 101,3 MW. The six electricity companies constructed their own PV power plants or purchased PV electricity from the private source. In 2011, 31,7 MW was approved under this program. From the year 2012, the RPS (Renewable Portfolio Standard) scheme fully replaced the existing FiT scheme. PV has its own set-aside amount in the RPS of 1,2 GW for the four years covering 2012 to 2015. The plan was shorten by one year in order to support the local PV industry. In 2012, about 162 MW was installed under this program.

Feed-in Tariff Program

Until 2011, a total of 500 MW was installed under this scheme. In 2011 alone, 79 MW were installed. FiTs in 2010 and 2011 were reduced by 10 to 15% compared with the previous year. For BIPV, 10% bonus was given. A BIPV system larger than 1 MW is accounted as a ground installed system. The FiT scheme ended at the end of 2011.

Building Subsidy Programme(Formerly General Deployment Subsidy Program)

The Government supports up to 50% of installation cost for PV systems for systems below

50 kW. In addition, the Government supports 80% of initial cost for special purpose demonstration and pre-planned systems in order to help the developed technologies and systems to diffuse into the market. This is the “Test-period deployment subsidy program.” In 2012, 115 PV systems with the total of 2,3 MW were installed by this program. Until the end of 2012, about 16 MW capacity and 690 PV systems benefited from this program. Various grid-connected PV systems were installed in schools, public facilities, welfare facilities as well as universities.

Regional Deployment Subsidy Programme

The government supports 50% of installation cost for PV systems owned and operated by local authorities. Until the end of 2012, about 60 MW benefited from this program.

NRE Mandatory Use for Public Buildings

The new buildings of public institutions, the floor area of which exceeds 1 000 square meters, are obliged by law to use more than 10% of their total expected energy by the newly installed renewable energy resource systems. Public institutions include state administrative bodies, local autonomous entities, and state-run companies. The building energy mandate percentage will increase up to 20% by 2020. In 2012 alone, 32 MW was installed under this program, the cumulative total capacity reaching about 90 MW at the end of 2012.

Malaysia

The PV market grew significantly in 2012, however remaining at a low level (2 MW for residential installations, 20 MW for non-residential). 34 MW of PV systems are currently producing electricity, including off-grid systems. In addition to grid-connected PV installations, 8 MW of off-grid systems were in operation in the country. Numbers have been revised downwards in 2012.

The National Renewable Energy Policy and Action Plan (NREPAP) provides long-term goals and commitment to deploy renewable energy resources in Malaysia. The objectives of NREPAP include not only the growth of RES sources in the electricity mix but also reasonable costs and industry development.

The Sustainable Energy Development Authority Malaysia or SEDA Malaysia was established on 1st September 2011 with the important responsibility to implement and administer the Feed-in Tariff mechanism.

At end of December 2012, SEDA Malaysia had approved a total of 914 applications for 168,98 MW) for PV and these constituted 95,2% of the total applications approved under the FiT programme. Solar PV constituted 37,48% from the total installed capacity approved under the Programme. The FiT Programme is funded by a Renewable Energy Fund (RE Fund) funded by electricity consumers via a 1% collection from the consumers’ monthly electricity bills. Small consumers with consumption below 300 kWh per month are exempted from contributing to the fund. Due to the limited amount of the RE Fund, the FiT is designed with a cap for each technology.

BIPV installations are incentivized with an additional premium on the top of the Feed-in Tariff.

Bangladesh

The Government of Bangladesh has been emphasizing developing solar home systems (SHS) as about half of the population of 150 million has no access to mains electricity. Under the Bangladesh Climate Change Strategy and Action Plan 2009 and supported by zero-interest loan from the World Bank Group as well as support from a range of other donors the government is promoting incentive schemes to encourage entrepreneurs who wish to start PV actions, at present lead by the Infrastructure Development Company Ltd. (IDCOL) working with about 40 NGOs.

Thanks to the fall in prices of the systems and a well-conceived micro-credit scheme (15% of the 300 USD cost is paid directly by the owner and the rest is financed through a loan), off-grid PV’s deployment exploded in recent years. The number of systems in operation is estimated around 2 million SHS. 2,5 million SHS are targeted for 2014. Average size of the system is around 50 - 60 W; for lighting, TV connections and mobile phone charging. Local industries are involved in the process and could replicate this in other countries. IDCOL also targets 10 000 irrigation PV pumps (80 MW).

India

In a context of severe electricity shortages, the need for electricity in India hasn't until now really developed the PV market at the size that could be expected from a country of one billion people. The Indian market achieved close to 1 GW in 2012, powered by various incentives in different states, with an installed capacity close to 1,2 GW of grid connected systems by end of 2012. The state of Gujarat accounted for a large part of the market.

The PV market in India is driven by a mix of national targets and support schemes at various legislative levels. The Jawaharlal Nehru National Solar Mission aims to install 20 GW of grid-connected PV system by 2022 and an addition 2 GW of off-grid systems, including 20 million solar lights.

In the last quarter of 2012, the states of Tamil Nadu, Andhra Pradesh and Chhattisgarh have announced policies targeting 5 GW of solar photovoltaic (PV) installations over the coming years.
The NSM has proposed a target of 6,3 GW for its second phase starting in 2013 and going to 2017, with up to 5,3 GW of the announced capacity relying on the Renewable Purchase Obligation (RPO) targets set by states. The main issue will lie in the lack of enforcement policies linking to the quota obligation that could make the translation into real projects more complicated than expected. Utilities have a quota of renewable energy that can be considered quite low. It starts at 0,25% and will grow to up to 3% in 2022.

At state level, Tamil Nadu and Rajasthan have implemented solar policies based on feed-in tariffs. However, the financial viability is not guaranteed and could put the PPAs at risk.

Interest rates remain quite high in the country for PV projects, around 13% and increase the LCOE of PV electricity.

Finally, 2 GW of off-grid PV systems should be installed by 2017.

Thailand

At the end of 2012, the cumulative grid-connected PV power reached 383 MW or 92% of total solar power installation, with between 30 to 40 MW of off-grid applications.

The introduction of a feed-in premium or "adder" in Thailand in 2007 aimed at promoting the development of grid-connected PV. This "adder" comes in addition to the regular tariff of electricity, around 3 THB/kWh. While the government planned initially 500 MW of solar installations (PV and CSP together) by 2020, the target was rapidly overshot, with more than 3 000 MW of solar project proposals that have applied for the financial support scheme. New applications for the Very Small Power Producer (VSPP) and the Small Power Producer (SPP) scheme have been stopped by the government due to the huge number of projects received.

In addition, the "adder" prices for solar generation have been decreased from 8 THB per kWh (0,258 USD/kWh) to 6,5 THB per kWh (0,2098 USD/kWh).

At the end of 2011, the solar power generation target was increased to 2 000 MW, in order to cope with the new Energy Development Plan. This one targets 25% of renewable energy under the 10-Year Alternative Energy Development Plan (2012-2021).

In 2013, the solar power generation target has been increased to 3 GW together with the reopening of the solar PV rooftop VSPP scheme with a new feed-in tariff (100 MW for small rooftops below 10 kW; 100 MW for commercial and industrial rooftops between 10 and 250 kW and large scale rooftops between 250 kW and 1 MW). FiT prices have been fixed at 6,96 THB per kWh (0,2245 USD per kWh) for residential size, 6,55 THB per kWh (0,2113 USD per kWh) for medium buildings and industrial plants and 6,16 THB per kWh (0,1987 USD per kWh) for large buildings and industrial plants. The FiT will be paid during 25 years.

In addition, the Thai Government also approved the so-called "community solar" power generation scheme of 800 MW. This scheme will be implemented by cooperation between the Ministry of Energy and the National Village and Urban Community Office, under the Prime Ministry Office. The stepwise FiT prices for this scheme will decrease from 9,75 THB per kWh for the first three years, down to 6,5 THB per kWh in the seven following years and finally 4,5 THB per kWh until the 25th year. These 800 MW are planned to be completed by the end of 2014. Apart from these two promotion schemes, the Government also approved 25 MW of rooftop PV installations for Government buildings.

With these schemes, Thailand aims at continuing the deployment of grid-connected PV in the rooftop segments, after a rapid start in the utility-scale segment.

Taiwan

In 2012 Taiwan installed about 104,5 MW mostly as grid-connected roof top installations. The total installed capacity at end of 2012 is estimated at 222 MW. The official target for 2013 has been set-up at 130 MW.

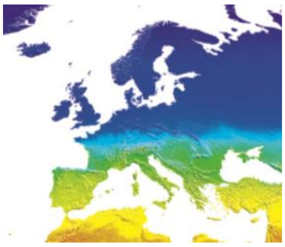
The market is supported by a feed-in tariff scheme guaranteed for 20 years and administered by the Bureau of Energy, Ministry of Economic Affairs. This scheme is part of the Renewable Energy Development Act (REDA) passed in 2009 that drove the development of PV in Taiwan. The initially generous feed-in tariff was combined with capital subsidy. It has later been reduced and now applies with different tariffs to rooftops and ground-mounted systems. Larger systems and ground based systems have to be approved in a competitive bidding process based on the lowest FiT offered. A bidding process for 2013 will target 90 MW of additional PV systems. In order to cope with declining prices of PV systems, feed-in tariffs were reduced in 2012.

The target is split in two parts: One for systems granted through the bidding process and one for the non-bidding process. Bids are scheduled monthly.

Property owners can receive a further capital subsidy. It is the intention to favor small scale roof-tops at the expense of larger systems, in particular ground based installations. So far, agricultural facilities and commercial rooftops have led the market. The country targets 420 MW of PV installations in 2015 and 3,1 GW in 2030.

In 2012, Taiwan launched the "Million Roof Solar Project" aiming at developing the PV market in the country, with the support of municipalities. The authorization process has been simplified in 2012 in order to facilitate the deployment of PV systems and will most probably ease the development of PV within the official targets.

Other Asian countries are seeing some progress in the development of PV. **Pakistan** is expected to approve a 700 MW solar plant in the Punjab region in 2013. This comes in addition to a previous memorandum of understanding signed with various providers in order to develop hundreds of MW in several places in the country. **Brunei** is considering a Feed-in Tariff scheme and the **Philippines** plans at least 20 MW of ground mounted PV with 10 MW commissioned in 2013. **Indonesia** has seen the first 50 MW phase of a large 250 MW project secured end of 2012. It could see in addition a 100 MW plant built but no deadline is known so far. In addition it aims to launch in 2013 a FiT scheme that could be accompanied with a bidding process. **Myanmar** has signed a memorandum for building 210 MW. In **Singapore**, 1 MW of PV on rooftops has been installed in 2012. **Uzbekistan** has the intention to develop 100 MW of PV developed by the Asian Development Bank.



Europe

Europe is leading the development of PV for almost a decade now and represented more than 50% of the global PV market in 2012. European countries installed close to 70 GW of cumulative PV capacities with 17,3 GW installed in 2012 only.

Austria

Austria's support for PV relies on a mix of capped feed-in tariff and investment grants. Due to a cap for the tariffs, the development of PV in Austria remained quite low, with a market below 100 MW until 2012. In 2012 alone, the market progressed faster, with 175 MW connected to the grid. Even if the yearly budget to support PV deployment has grown, the market is still capped and not allowed to grow freely as in several other countries. This explains why, despite the country's attractiveness (good irradiation conditions existing in the country, coupled with reasonable cost of capital), the development of PV was much slower than in Germany or Italy.

70% Renewables

The share of renewable electricity sources in the country is high with close to 70% of the electricity demand covered. The share of hydro in particular is exceptionally high, which also allows the electricity system to benefit from a reserve of flexibility that will ease the PV development in the coming years. The major challenge lies in the ability to upgrade the electricity market functioning where the prices went down quite quickly in recent years.

Belgium

Belgium is a complex case with different PV incentives in the three regions that compose the country, but an electricity market that covers the entire country. Organized as a federation of regions (Flanders, Wallonia and Brussels region), the country set up regulations that are sometimes regional, sometimes national.

Despite this organisation, all three regions selected an RPS system, with quotas for RES that utilities have to provide, and set-up three different trading systems for green certificates. In addition, the price of green certificates is guaranteed by the national TSO that charges the cost to electricity consumers.

For small rooftop installations below 5 or 10 kW, a net-metering system exists across the country. And until 2010, further grants were paid in addition to other support schemes while the tax rebates have been cancelled in 2012.

Flanders started to develop first and installed close to 2 GW of PV systems in a few years. In Wallonia, the market was started with a two year delay and remains largely concentred in the residential and small commercial segments with more than 500 MW at the end of 2012. In Flanders, large rooftops and commercial application have developed from 2009. In Wallonia, conditions of self-consumption and energy efficiency considerably limit development of the commercial and industrial segments. So far in Brussels, the city landscape limits PV development.

The market grew very rapidly at quite a high level in both Flanders and Wallonia over the years, mainly due to a slow adaptation of all support schemes to declining PV system prices. The market boom that occurred in Flanders in 2009, 2010 and 2011 was followed by a rapid growth in Wallonia in 2011 and especially 2012 with 260 MW installed solely in the residential segment of the 3 million inhabitants region.

After this boom, the reaction was to dramatically reduce financial incentives in order to put the brakes on fast PV deployment.

At the end of 2012, a grid injection fee (to be paid annually and power-based) was introduced in Flanders for systems benefiting from the net-metering scheme and a similar scheme will be discussed in Wallonia as well. The goal of this policy is to avoid losses in the revenues of grid operators and can be seen as a compensation for the net-metering system. Meanwhile, this has raised some legal questions due to the retroactivity of such a measure.

In general, the cost of support schemes has started to cause some growing discontent in the population, and some policy makers are pushing to reduce the already granted revenues from the green certificates schemes, which will lead to market instability in 2013, and most probably a rapid halt.

Denmark

By the end of 2011, only 17 MW were installed in Denmark. While grid-connected installations were the majority, off-grid was installed for instance in Greenland for stand-alone systems for the telecommunication network and remote signalling.

The net-metering system set by law for private households and institutions led to a rapid market expansion in 2012, with about 315 MW installed (61 000 systems), an increase of 2 000% compared to 2011. The high electricity prices combined by decreasing system costs for PV systems made this fast development possible.

In November 2012, the government reacted to this high level of market development and modified the net-metering law. While the compensation between PV electricity production and local electricity consumption occurred during the entire year, the new regulation allows compensation to take place during only one hour. This change limits de facto the competitiveness of PV installations in Denmark and will have consequences on the market evolution in 2013. In addition to these changes, the duration of the old net-metering system for existing systems has been reduced to 10 or 15 years depending on the installation time. Finally the electricity exported to the grid will have a tariff of 1,30 DKK/kWh, around 40% below the retail electricity prices. These changes will impact the perception of PV and could lead to a clear standstill in 2013.

The EU directive on energy consumption in buildings was minted into a revised national building code in 2005 – and moved into force early 2006 – which specifically mentions PV and allocates PV electricity a factor 2.5 in the calculation of the "energy footprint" of a building. However, due to the inertia in the construction sector, it was possible to detect some real impact on PV deployment only in 2009, as developers, builders and architects openly admitted the inclusion of BIPV in projects due to the building codes.

This trend was markedly strengthened during 2012. Ongoing political discussions both on the EU level and nationally indicate an upcoming further tightening of the building codes, which may further promote BIPV; and the future energy requirements in the building codes are now known up to 2020 with many new buildings in compliance with these future codes.

European Union

In addition to all measures existing in member states, the European Union has set up various legislative measures that aim at supporting the development of renewable energy sources in Europe.

The most well-known measure is the renewable energy directive that imposes all countries to achieve a 20% reduction of greenhouse gases emissions by 2020, together with 20% of energy efficiency and 20% of renewable energy sources in the energy mix. Since that directive from 2009 let all member states decide about the way to achieve 2020 targets, PV targets were set up in various ways. Currently, the European Commission works on possible 2030 targets in order to continue promoting the development of renewables after 2020.

Amongst other measures, the so-called EPBT directive defines a regulatory context for energy performance in buildings and paves the way for near-zero and positive energy buildings.

The grid development is not forgotten: The financing of transmission system operators' new investments is discussed as well as the harmonization of grid connection codes for all generators, including PV systems. In addition, the question of the future of electricity markets is central in all electricity sector's discussions. Some pretend that the rapid development of renewables electricity sources in Europe has caused the price of electricity to decrease significantly on electricity markets, putting the financial viability of several large utilities at stake. The growing competition of renewables with conventional sources of electricity was even clearer at the end of 2012 when for the first time, renewable electricity sources produced more electricity than nuclear power plants in Europe (25 against 24%). The role of PV is questioned due to the observed price decrease during the mid-day peak that is attributed to PV power production.

After more than a decade of rapid increase (more than 120 GW of gas power plants have been connected to the grid since 2000), they suffer from reduced operating hours and lower revenues, because of the progresses of renewable sources. Fearing for generation adequacy issues in the coming years, some are pushing for Capacity Remuneration Mechanisms in order to maintain the least competitive gas plants on the market. While the impact of PV on this remains to be proven with certainly, the future of the electricity markets in Europe will be at the cornerstone of the development of PV.

Energy is not the only field of competence where European Institutions have an impact on PV development: 2012 saw a large and long debate on the WEEE directive. The inclusion of PV in this regulation for end-of-life takeover and recycling of electronic equipment waste has been explained above in the chapter on sustainability.

France

France initially supported the PV development through a pure Feed-in Tariff system, paid by a contribution of electricity consumers. The specifics of this system were to support BIPV systems rather than conventional BAPV systems only. Due to a surge in the demand at the very end of 2010, the government decided to constrain the PV development to 500 MW a year. This new support framework was put in place in March 2011 after a moratorium. It allows systems of up to 100 kW to benefit from a remunerative FiT level; for systems larger than 100 kW the FiT is low compared to other EU countries (slightly above 0,10 EUR/kWh) and induces the development of very competitive projects. Alternatively, projects starting at 100 kW can apply to calls for tenders. The waiting time to apply for tenders makes this scheme very complex due to rapid changes in system prices. For instance: The results of the mid 2011 tendering scheme were not known until mid-2012, shifting the market development by six months to more than a year and the connection to the grid came even later.

In such a situation, installation level in France went down to 1 079 MW in 2012 from 1 759 MW in 2011 and this trend should continue in 2013. A part of PV installations has occurred in the overseas department of France, around 300 MW, but this slowed down in 2012 due to grid limitations. The rooftop market represented more than 750 MW, and the utility-scale segment around 320 MW.

The support to BIPV explains the relatively high cost of support schemes in France in general. In addition, France has introduced a 5 to 10% increase of the feed-in-tariff levels at the end of 2012 if the system uses components produced in the European Economic Area (larger than the European Union). This local content requirement will not show its effects before 2013.

Comments

Relatively low retail prices for electricity (compared to neighbouring countries such as Germany or Italy for instance) could delay the achievement of PV competitiveness in the country while the large share of nuclear could be an issue to integrate high shares of variables renewables such as PV into the grid.

Germany

With 3 years in a row above 7 GW of PV systems connected to the grid, Germany has installed at least 32 GW of PV systems until the end of 2012, which is the world record. This has been achieved thanks to a combination of several elements:

- A long term stability of support schemes;
- The confidence of investors:
- The appetite of residential, commercial and industrial building owners for PV.

Feed-in Tariff with a Corridor

The EEG law has introduced the Feed-in Tariff idea and has continued to promote it. It introduces a FiT for PV electricity that is mutualised in the electricity bill of electricity consumers. Exemption is applied to energy-intensive industries. With the fast price decrease of PV, Germany introduced the “Corridor” concept in 2011: A method allowing the level of FiTs to decline according to the market evolution. The more the market was growing during a defined period of time, the more the FiT levels were lowered. In the first version, the period between two updates of the tariffs was too long (up to 6 months) and triggered some exceptional market booms (the biggest one came in December 2011 with 3 GW in one single month). In September 2012, the update period was reduced to one month, with an update announced every three months, in an attempt to better control market evolution. The government targets remain around 2,5 to 3,5 GW per year.

In September 2012, Germany abandoned FiT for installations above 10 MW in size.

Self-consumption

The self-consumption premium that was paid above the retail electricity price was the main incentive to self-consume electricity rather than injecting it into the grid. The premium was higher for self-consumption above 30%. In 2012, the premium was cancelled when FiT levels went below the retail electricity prices. In the same idea, for systems between 10 kW and 1 MW, a cap was set-up at 90% in order to force self-consumption. If the remaining 10% have to be injected anyway, a low market price is paid instead of the feed-in tariff.

In 2013, the market should decrease, under the double effect of lowered FiTs and the end of large installations. A newly installed programme of incentives for storage units was introduced 1st of May 2013, which aims at increasing self-consumption and reduce the share of FiT-driven PV in Germany. The success of the programme is still under investigation.

Market Integration Model

Opposite to self-consumption incentives, Germany pushes PV producers to sell electricity on the electricity market through a “market premium”. The producer can decide to sell its electricity on the market during a period of time instead of getting the fixed tariff and receives an additional premium on the top of the market price. The producer can go back and forth to the FiT system or the market as often as necessary. Less than 3 GW of PV installations were selling on the market under this model at the end of 2012.

Grid Integration

Due to the high penetration of PV in some regions of Germany, new grid integration regulations were introduced. The most notable ones are:

- The frequency disconnection settings of inverters (in the past set at 50,2 Hz) has been changed to avoid a cascade disconnection of all PV systems in case of frequency deviation.
- Peak shaving at 70% of the maximum power output (systems below 30 kW) that are not remotely controlled by the grid operator.

Comments

The German PV market is one of the most competitive with low system prices, numerous qualified installers and the population’s strong confidence in the energy transformation that has been initiated by the German government. This has led to the huge installed capacity in Germany.

Germany also shows the strong reactivity of markets in anticipation of further FiT reductions, and highlights the need for a tight and dynamic market control mechanism. It also shows that market development is not anymore a question of the level of FiTs but rather a global trend, pushed by self-consumption and similar business models.

Italy

Since 2008 the FiT scheme in place has allowed for an increasing market development, resulting in a boom in installations in 2010 and 2011 and connections to the grid in 2011 and 2012. From a regulatory standpoint, 2011 and 2012 were two years of regulatory changes for the PV sector in Italy. 2011 started with a new 3rd regulation on energy (the '*Conto Energia')*¸ which was soon replaced by a 4th *Conto* from June 2011, and the 5th Conto from July 2012.

A Capped Cost for PV Financial Support

Italy has made the choice of Feed-in Tariffs to develop the PV market, with additionally a self-consumption regulation introduced in 2011 (the "*Scambio Sul Posto*"). The cost of the FiT for PV electricity is mutualised in the electricity bill of electricity consumers and reached 5,5 Billion EUR at the end of 2011 and the annual cost of 6,45 billion EUR at the end of 2012.

The FiT law will stop when the annual costs of all FiTs reaches 6,7 billion EUR a year; which will happen in 2013. It is not known on which legal basis PV will develop after this milestone is reached but in all cases no more support through FiTs is expected after that. Tax credit is an alternative incentive measure that is used as well.

A 5% increase of the feed-in tariff is granted for systems using European components.

Self-Consumption

The Scambio Sul Posto is an alternative support scheme that favours self-consumption through an economic compensation of PV production and electricity consumption for systems up to 200 kW. This net-billing scheme was revised in August 2012: New PV systems can benefit from a self-consumption premium in complement to the FiT for the injected electricity, pushing PV systems to be progressively adjusted to the consumption pattern of users.

Comments

From a market evolution perspective, Italy holds the world record when looking at the number of systems connected to the grid in 2011: 9,3 GW were officially granted an access to the electricity network that year. While a part of these 9,3 GW could have been installed in 2010 and connected in 2011, this high level has been reached mainly due to the decline in PV system prices that wasn't accompanied by a late FiT decrease. While this situation improved significantly in 2012, it kept the market at quite a high level with more installations expected in 2013. With high solar resources, especially in the south and relatively high retail electricity prices, Italy could become a haven for self-consumption-driven installations. It should be mentioned that Italy incentivized BIPV and CPV systems.

The Netherlands

Until 2003, the Dutch PV market developed thanks to an investment grant that was extremely successful. Due to budget reallocation, the grant was cancelled and the market went down to a low level.

From 2008-2009 the government introduced a new Feed-in Tariff programme with a financial cap. This revitalized the market until the end of the programme in 2010.

Since 2011, the main incentive in the Netherlands is a net-metering scheme for small residential systems up to 15 kW and 5 000 kWh. This triggered an important market development in 2012 with at least 195 MW installed in the country, pushing the installed capacity up to 340 MW. According to the grid operators, the total installed capacity in the country could approach 370 MW.

In July 2012, the government granted 52 million EUR for PV development, through direct funding of PV investments, to be split between 2012 and 2013. In addition, some provinces and municipalities are providing additional incentives to install PV systems.

This environment is triggering the development of new business models. For example, contracts to purchase electricity from neighbours are developing, resulting in new "community-based" systems. The Dutch market is very competitive and it will be interesting to observe the fast evolution of net-metering and the potential reaction from grid operators, while high electricity prices are making grid parity accessible in the residential segment.

Norway

The PV market in Norway continues to be stable at a low level. A total of approximately 470 kW of PV power was installed during 2012. Most installations are off-grid systems.

The total installed capacity in 2012 is approximately 10 MW.

The country is rather known for its PV producers rather than its market but the development of niche markets in this Nordic country is an indication of the potential of PV for off-grid applications all over the world, whatever the weather conditions. The market refers to both the leisure market (cabins, leisure boats) and the professional market (primarily lighthouses/lanterns along the coast and telecommunication systems). Exceptions are a few business and public actors who have integrated PV in large buildings, and some private homebuilders who installed PV systems in their private grid-connected houses: This market exists in most countries and is driven by passionate people. Some industrial applications involving small installations, such as weather stations, stations for collecting hydraulic data etc., constitute also an important market segment. New PV equipment is mostly used in addition to older ones.

Cabins and Recreational Homes.

The leisure segment still accounts for the larger part of the Norwegian market, with 85-120 W being a representative typical pico PV system size. Applications for leisure boats and recreational vehicles have also grown over the past years with the typical system size of 50 W. As PV-prices continue to drop, a large number of users buy additional modules to add to their original systems. At the same time, the original panel continues to operate.

Up to 1992, the demand for PV installations in cabins and recreational homes constituted the most important market segment. An increasing number of users now purchase additional PV capacity to serve home appliances such as TV, refrigerators, etc. Replacement of older systems also creates some market growth. Hybrid systems, combining PV-equipment with gasoline or diesel fuelled generators, charging equipment, rectifiers etc., are becoming more common.

The market for so called autonomous “packages” with PV capacity 250 – 1 000 W, large battery banks (4 000 Ah and more) and diesel generators is increasing. The automatic regulation systems incorporated in these packages starts the generator when the load increases or the battery voltage drops below certain levels. Within certain limits, the user may act as if he/she was grid connected.

The specifics of Norway are making the PV market quite odd: Without specific support schemes, PV develops at a low level mainly in the fields of pico and hybrid PV systems. With already close to 60% of the energy mix coming from renewables and close to 100% of the electricity mix coming from hydro, the room for developing PV in Norway will most probably stay in the off-grid market for a while.

Portugal

66,1 MW were installed in Portugal in 2012, bringing the total installed capacity to around 220 MW. The market remains driven by the Feed-in Tariff scheme. The current support is split between micro-generation (below 5 kW) and mini-generation schemes (up to 250 kW). The latter one was not yet operational at the beginning of 2012, since projects were awaiting inspection but drove a part of the market that year. The feed-in tariff levels went down in 2012 to 151 EUR/MWh for mini-generation and 196 EUR/MWh for the first 8 years of production of micro-generation while the following 7 years benefit from a reduced FiT at 165 EUR/MWh. Commercial or industrial rooftop systems have not yet developed in a way that can be quantified. No licenses for ground-mounted systems were allocated in 2011, nor for 2012. In 2012, caps per segment have been reduced in order to limit the growth of PV installations.

Discussions on the potential adoption of a net-metering scheme were on-going in 2012, with a focus on the grid financing through grid costs and fees, even for PV system owners.

Portugal has set an objective of 1 GW of installed PV capacity by 2020.

Off-grid systems represent around 3,4 MW, with only 0,1 MW added in 2012.

Spain

In 2007 and 2008, Spain’s FiT programme triggered a rapid expansion of the PV market. Large PV installations developed fast and drove Spain to the very first place in the world PV market in 2008. In October 2008, a moratorium was put in place in order to control the growth and the FiT was granted only after a registration process capping the installations at 500 MW a year. After a low year 2009, due to the necessary time to put the new regulation in place, the market went down to between 200 and 450 MW a year. In 2012, 223 MW were installed in Spain.

Capped Retail Electricity Prices

Spain chose to finance the FiT costs by mutualising them on all electricity consumers, as many other countries have done. However, since the retail price of electricity in Spain is capped by a regulation, the government finances the cost difference directly.

Some measures were taken that have affected retroactively PV electricity producers, due to difficult economic conditions: The most visible one is the cap on hours during which PV installations received the FiT. The consequence is that FiTs are granted for a part of yearly production only, since the number of operating hours has been defined well below the real production hours of PV systems in Spain.

This was done in a context of overcapacity of electricity plants in the country, combined with limited interconnections. This situation leads to the opposition of conventional stakeholders and grid operators in such a way that it forced the government to decide a moratorium for all new renewable and cogeneration projects benefiting from FiTs ("Special regime") from January 2012.

Comments

Finally, at the end of September 2012, Spain imposed a new tax on all generation technologies to cover the electricity prices deficit, reducing the profitability of existing PV plants. Discussions on a possible net-metering system were not conclusive in 2012 and even self-consumption could become difficult to implement in 2013.

Sweden

The PV power installation rate in Sweden continued to increase in 2012 and a total of 8,4 MW was installed, almost twice as much as the 4,4 MW that was installed in 2011.

The off-grid market grew from 0,7 MW in 2011 to 0,8 MW in 2012. As in 2011, and in the same way as in many European countries, the large increase of installed systems occurred within the submarket of grid-connected systems. Around 7,6 MW was installed in 2012 which is 3,9 MW more than the 3,7 MW that was installed in 2011. The strong growth at a low market level in the Swedish PV market is mainly due to lower module prices, a growing interest in PV and the direct capital subsidy that was in place in 2012.

Historically, the Swedish PV market has almost only consisted of a small but stable off-grid market where systems for recreational cottages, marine applications and caravans have constituted the majority. This domestic off-grid market is still stable and is growing slightly. However, in the last five years, more grid-connected capacity than off-grid capacity has been installed and Sweden now has almost three times more grid-connected PV capacity than off-grid capacity. The grid-connected market is almost exclusively made up of roof mounted systems installed by private persons or companies. So far, only a couple of relative small systems can be seen as centralized systems (0,74 MW installed in 2012).

Incentives

A direct capital subsidy for installation of grid connected PV systems that have been active in Sweden since 2009 was first prolonged for 2012 and in December 2012 the government announced that it would be extended until 2016 with a budget of 210 million SEK for the years 2013-2016.

During 2011, the subsidy covered 60% (55% for big companies) of the installation cost of PV systems, including both material and labor costs. For 2012, this was lowered to 45% to follow the decreasing system prices in Sweden and was further decreased in the new 2013-2016 ordinance to 35%. The subsidy in 2011 had an upper limit in cost at 2 million SEK per PV system and the system could cost a maximum of 75 000 SEK plus VAT per installed kW. These numbers were decreased the 2012 to 1,5 million SEK per PV system (and a maximum of 40 000 SEK/kW) and in the 2013-2016 ordinance, funds can only be applied for if the system cost less than 1,2 million SEK in total (and less than 37 000 SEK/kW).

The waiting time for a decision about the investment subsidy is quite long; generally about 1-2 years.

An investigation about the introduction of a net-metering system was started in 2012 by the Ministry of Energy. In the meantime, some utilities have decided to put similar schemes in place.

Additionally, a tradable green certificates scheme exists since 2003, but only 10% of PV installations are using it so far, because of the insufficient level of support for solar PV installations.

Switzerland

226 MW were connected to the grid in Switzerland in 2012, more than the cumulative capacity at the end of 2011. Almost 100% of the market consists in rooftop applications and the few ground mounted applications are very small in size. Off-grid applications accounted for 100 kW in 2012. Large scale ground mounted is non-existent in Switzerland. Close to 433 MW of grid-connected applications are producing electricity in the country next to some 4,6 MW of off-grid applications.

This was achieved in 2012 thanks to a decrease of the feed-in tariffs levels, in line with the PV system cost decrease, that allowed raising the cap on installations.

Besides the (capped) national FiT scheme there are still many regional, local and utility support schemes: Those are either based on direct subsidies or feed-in tariffs equal or below those on the federal level.

Single family houses represent around 15% of the market, and around 20% with multi-family buildings. The commercial and industrial sector represents around 40% of installations, while agriculture adds another 30%, a very large share in Europe. The last 10% are official buildings or public transport buildings.

The size of residential buildings increased from around 3 kW to 15 kW while the average for single family houses is quite high with 7,5 kW. This is encouraged by the absence of size limit for the Feed-in Tariff scheme that allows covering of the entire roof rather than delivering the same amount of electricity as the yearly consumption. The current schemes allow also east and west facing PV roofs to be profitable, which could be seen as a way to ease grid integration.

In the same way as in many countries, the nuclear disaster in Japan in 2011 has increased the awareness of electricity consumers concerning the Swiss electricity mix. This pushed policy makers in 2011 not to replace existing nuclear power plants at the end of their normal lifetimes. Consequently, PV, with other sources of electricity became perceived as a potential source of electricity to be developed. Preliminary new goals for PV electricity in Switzerland show levels of 15% and above, but this will have to be confirmed in the coming years. The recognition of positive energy buildings in the future could help to further develop the PV market in Switzerland, using regulatory measures rather than pure financial incentives.

United Kingdom

925 MW of PV systems have been installed in 2012 in the UK, bringing the total installed capacity to 1 829 MW. In comparison to 2011, the progress was relatively limited, with 813 MW having been installed in 2011.

The market is driven by two main support schemes: A generation tariff coupled with a feed-in premium and a system of green certificates linked to a quota (called ROC, for Renewable Obligation Certificates). The generation tariff is granted for small size PV systems. Systems below 30 kW receive in addition to the generation tariff, a bonus for the electricity injected into the grid (the so-called export-tariff, a feed-in premium above the generation tariff), while the self-consumed part of electricity allows for reducing the electricity bill. This scheme can be seen as an indirect support to self-consumption: The export tariff being significantly smaller (0,045 GBP/kWh) than retail electricity prices (up to 0,14 GBP/kWh). Above 30 kW, excess electricity is sold on the electricity market.

New tariffs in 2012, which decreased by over 50% from the level of support for small-scale PV systems, have somehow reduced the dynamism in the small-scale business but didn't halt the market.

For larger systems, UK has implemented its own RPS system, called ROC: In this scheme, PV producers receive certificates with a multiplying factor. This scheme applies to buildings and utility-scale PV systems. This system could be replaced in 2014 by a market premium using a Contract for Differences to guarantee a fixed remuneration based on a variable wholesale electricity price.

In addition, PV system owners can benefit from tax breaks and VAT reduction.

Bulgaria

Bulgaria experienced in 2012 a very fast PV market boom that was fuelled by relatively high feed-in tariffs. Officially 767 MW of PV systems were installed in this country with 7 million inhabitants in a bit more than one year, creating the fear of potential grid issues. In addition to possible retroactive measures aiming at reducing the level of already granted feed-in-tariffs, Bulgarian grid operators have opted for additional grid fees in order to limit market development.

Czech Republic

Driven by low administrative barriers and a profitable feed-in tariff scheme, the Czech PV market boomed in 2009 and especially in 2010. With more than 2 GW installed, only some 113 MW of installations occurred in 2012 in the country. Composed of large utility-scale installations, the Czech PV landscape left little place to residential rooftop installations that are now the only installations that can benefit from a Feed-in-Tariff system.

The reason for this sharp market decline was a freeze of grid connection licensing decided in 2010 and released partially in 2011. The Czech TSO imposed a limit of 65 MW for new solar and wind installations in 2012. Up to this level, new projects were assessed on a case-by-case basis. The key to further PV deployment lies in the residential and commercial rooftop segments, where self-consumption could be the main driver, minimizing transmission network congestion on very sunny days and during low-consumption periods. The rapid and uncontrolled growth of PV in the country had led to negative feelings towards this technology among the population and could have compromised its short to medium term development.

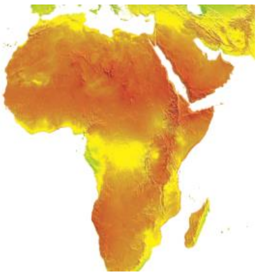
Greece

In 2012, Greece installed 912 MW of PV systems, and reached more than 1,5 GW of installed capacity. The market is driven by feed-in tariffs that were adjusted at the beginning of 2012 and again in September to be more in line with the evolution of PV system prices. The installations are mainly concentrated in the rooftop segments (commercial and industrial segments mainly), with around 10% only for the utility-scale one. With dozens of islands powered by diesel generators, the deployment of PV in the Greek islands went quite fast in 2012: 112 MW have been installed on islands not connected to the mainland grid. Due to the rapid market uptake, grid operators asked in 2012 to slow down the deployment of PV, in order to maintain the ability of the grid to operate within normal conditions. This will most probably slow down the development of PV in Greece in the second half of 2013.

Due to the country irradiation levels, the Helios project was considered in 2012 as an option to develop PV for electricity exports to other European countries in general and Germany in particular. Greek policy makers and the European commission showed some interest despite the high constraints associated today to this project.

Other European countries have experienced some market development in 2012, most of the time driven by Feed-in-Tariff schemes. The small country of Slovenia installed more than 115 MW while larger countries such a Romania and Poland are still waiting for an adequate scheme that could trigger PV deployment. 26 MW were installed in **Romania** but only a mere 4 MW in **Poland** that expects a support scheme for PV in 2013 or even later. **Slovakia** experienced very fast market development in 2011 with 321 MW installed but only 15 MW with reduced incentives and a rather negative climate towards PV investments in 2012. **Ukraine** has seen a

spectacular market development in 2011 and 2012 with 378 MW of large installations.
In total, the European markets represented in 2012 more than 17 GW of new PV installations and close to 70 GW of total installed capacity.



Middle East and Africa

Despite excellent solar irradiation conditions, few countries have yet to step into PV development. However the potential in the region is tremendous on the medium to long term. Several countries are defining PV development plans and industry starts to appear in some of them.

Israel

In 2012, Israel installed 47 MW of new PV systems, with 0,2 MW of off-grid applications, down from 120 MW in 2011. Most installations are rooftop based in all market segments, from residential households, to farms, industries, commercial buildings and municipalities. Only one unique very large scale system was operational in 2012 in the Arava Valley. Out of 8 800 systems installed in the country, 4 900 were on residential rooftops and the remaining on commercial and industrial buildings.

Numerous systems were being built at the end of 2012 which will most probably lead to installations level well above 150 MW in 2013.

In total, more than 236 MW of PV systems were operational in Israel at the end of 2012.

RPS and FiT

The first FiT system was enacted in 2008 by the government and led to a dramatic increase of PV systems installations. A quota system (RPS) was defined in 2009 in Israel, but it took until 2011 to complete it with the right quota for each technology. That year, the surprise ending of the second commercial quota mid-year led to a consequent lack of progress of medium-sized projects due to regulatory issues.

With the decline of PV system costs, the FiT system has been disregarded and will most probably be replaced by a new system called "VOR" (for Value of Renewable). This VOR can be understood as the value of RES electricity for the community, including the internalisation of some benefits such as energy security, environmental benefits and savings of energy imports.

In the meantime, FiT should be updated considering a global PV system cost index, rather than a local one, with automatic FiT levels updates. The replacement of FiTs should go in the combined direction of tenders and self-consumption schemes.

Turkey

With 5% of growth in only one year, the electricity demand in Turkey continues to increase. With 241,9 TWh in 2012 and a total installed capacity of electricity at 57,071 GW, Turkey relies mainly on hydro and fossil fuels for its electricity.

The Renewable Energy Law 6094 has introduced a purchase guarantee of 0,133 USD/kWh for solar electric energy production paid during ten years. In case of the use of local components for the PV system, additional incentives can be granted:

- PV module installation and mechanical construction, (+0,008 USD/kWh)
- PV modules, (+0,013 USD/kWh)
- PV cells, (+0,035 USD/kWh)
- Inverter, (+0,006 USD/kWh)

- Material focusing solar energy on PV modules, (+0,005 USD/kWh)

A total capacity of 600 MW solar power plants will be licensed by the end of 2013. It is expected that these MW-scaled plants will be put in operation until 2015. The Energy and Natural Resources Ministry will determine the new capacity after 2013. So far, the level of installations, including the year 2012 remained quite low.

The Energy and Natural Resources Ministry Strategic Plan aims to reach a 30% share of renewables (incl. hydro) in electric energy production by 2023. Although there is not a certain target for solar electricity generation by 2023, Turkey is willing to use its high potential. Cumulative grid-connected installed PV power in Turkey by the end of 2012 is estimated about 2,5 MW. Additionally, off-grid applications (about 6 MW cumulative capacities) account for around 70% of the cumulative installed PV capacity. However, the share of the grid-connected PV power systems grows year by year and 2013 is expected to be a critical year for the development of PV in Turkey. The most positive prospects are expected to be found in the small-scale PV market, since projects under 1 MW are not required to obtain a production license. Additionally, in the first license application round for a total of 600 MW PV projects larger than 1 MW has been completed by exceeding the proposed capacity by 15 times with 496 applications made to Energy Market Regulatory Authority (EPDK) reaching 8,9 GW in total. Turkish Electricity Transmission Company (TEIAS) is expected soon to publish the list of grid connection points and capacity of all the projects and announce the date, place and time for the tender.

Within this context, a rapidly growing market in near future in Turkey will not be surprising.

South Africa

The country is rolling up plans for a 5 GW park in Upington since 2011. The expected growth failed to happen in South Africa in 2012 with only some MW installed. Due to political decisions, projects that were supposed to be validated in 2012 took more time to be approved.

The REIPPP (Renewable Energy Independent Power Producer Procurement) programme to develop renewables in South Africa is a bidder programme that has granted PV projects in already two rounds. A third round of projects will be closed in 2013. The two first have approved numerous PV projects that are already being built (round 1) or just approved (round 2).

This will imply a major uptake of installations in South Africa in 2013 and in the coming years.

Other Countries

In MENA countries, the development of PV remains modest but almost all countries saw a small development of PV in the last years. There is a clear trend in most countries to include PV in energy planning, to set national targets and to prepare the regulatory framework to accommodate PV. **Dubai** announced that it aims for at least 1 GW of PV in 2030 with 13 MW being built in 2013 already and **Qatar** will launch its first tender in 2013 for 200 MW. With 22,5 MW, the **United Arab Emirates** are progressing slowly with only 3 MW added in 2012 while most North African countries remain below the 100 MW threshold, with 15 MW **Morocco** (of which the 2 GW Solar Plan for both CSP and PV hasn't yet materialized in a large development of PV), 15 MW in **Egypt**, and all other countries below 10 MW. In Morocco again, it is estimated that around 15 MW of PV systems have been installed off-grid; powering 50 000 houses with SHS PV systems. **Libya** has issued a call for tender for 14 MW of PV.

At the end of 2012, **Jordan** confirmed that it will launch a new Feed-in Tariff scheme for PV systems. The residential and commercial segments are targeted but the government would like local industrial players to take also the opportunity to develop PV. **Saudi Arabia** has drafted a master solar energy plan aiming for 40 GW of Solar Power by 2032, of which 15 GW could be PV. A first tender of 600 MW could be issued in 2013, for both CSP and PV.

In several other African countries, the interest for PV is growing, while the market hasn't really taken off yet. **Nigeria** has signed a memorandum to install 30 MW of PV in 2012. **Kenya** announced the intention of building a 50 MW plant but no precise date has been given yet. **Cameroon** is launching an 8 year, 500 MW project, with 100 MW that could be installed in 2013 already. **Angola** plans a 13 MW PV plant this year through public investment. **Ghana** has also plans to develop a 155 MW through a 20-year PPA starting in 2013 and being fully operational in 2015. At the beginning of 2013, **Senegal** has approved three PV plants with a total power of 50 MW. **Zimbabwe** plans 100 MW through its utility that will launch a call for tender. In **Ethiopia,** the government has signed an agreement to equip 25 000 homes with pico solar PV systems (8 to 130 W) in rural areas of the country.

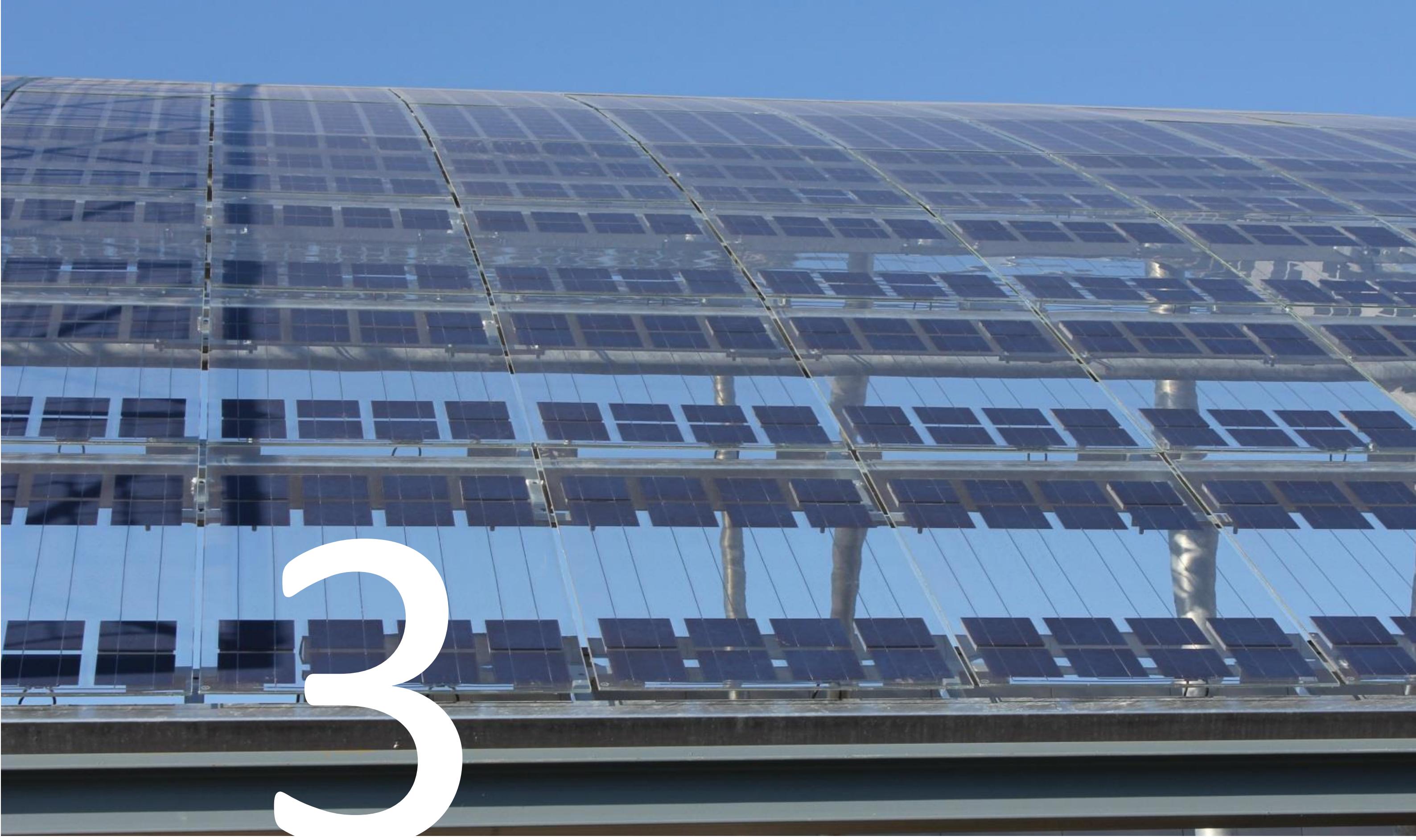
The ***Desertec*** project, aiming at providing solar electricity from MENA to Europe is pushing to adapt national frameworks in set demo projects in several countries in the MENA region. The exit of the Desertec Foundation (that initiated the concept of desert electricity) from the Desertec Industrial Initiative in charge of transforming the idea into reality is a rather bad signal given to such projects for the future.

Table 4: 2012 installations and Total Installed Capacity for Other Major (non IEA PVPS) PV Markets.

	2012 Installations	**Cumulative Capacity**	Source
Bulgaria	767	902	EPIA
Czech Republic	113	2072	EPIA
Greece	912	1543	EPIA
India	980	1096	Bridge to India
Rest of Americas	100	100	EPIA
Rest of Asia Pacific	200	200	EPIA
Rest of Europe	155	285	EPIA
Rest of Middle East and Africa	300	300	EPIA
Rest of the World	0	2098	EPIA
Slovakia	15	483	EPIA
Taiwan	104	222	TPVIA
Thailand	173	377	Thailand Ministry of Energy
Ukraine	188	378	EPIA
Total	4007	10056	
Notes:	The accuracy of the data presented in this table is smaller than official data delivered by IEA PVPS reporting countries.		
	Thailand's data are official and accurate		

Table 5 : Cumulative Installed PV Power (MW) in IE PVPS Countries and Major Other Markets : 2000-2012 Perspective

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Australia	25,3	29,2	33,6	39,1	45,6	52,3	60,6	70,3	82,5	104,5	187,6	570,9	1376,8	2415,0
Austria	3,7	4,9	6,5	10,3	16,8	21,1	24,0	25,6	28,7	32,4	52,6	95,5	187,2	362,9
Belgium	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	23,7	107,1	635,7	1054,9	2056,9	2698,4
Canada	5,8	7,2	8,8	10,0	1,0	13,9	16,8	20,5	25,8	32,7	94,6	281,1	558,3	827,0
China	0,0	19,0	23,5	42,0	52,1	62,1	69,9	79,9	99,9	139,9	299,9	799,9	3299,9	6799,9
Denmark	0,0	1,5	1,5	1,6	1,9	2,3	2,7	2,9	3,1	3,3	4,6	7,1	16,7	332,2
France	0,0	0,0	0,0	0,0	0,0	26,0	33,0	43,9	81,5	185,9	377,2	1194,3	2953,4	4032,6
Germany	30,2	89,4	206,5	323,6	473,0	1139,4	2071,6	2918,4	4195,1	6153,1	9959,0	17372,2	24857,5	32461,6
Israel	0,0	0,0	0,0	0,0	0,0	1,0	1,0	1,3	1,8	3,0	24,5	70,1	189,7	236,7
Italy	18,5	19,0	20,0	22,0	26,0	30,7	37,5	50,0	120,2	458,3	1181,3	3502,3	12802,9	16450,3
Japan	208,6	330,2	452,8	636,8	859,6	1132,0	1421,9	1708,5	1918,9	2144,2	2627,2	3618,1	4913,9	6631,7
Korea	3,6	4,1	4,9	5,4	6,0	8,5	13,5	35,8	81,2	356,8	523,7	650,3	729,2	959,2
Malaysia	0,0	0,0	0,0	0,0	0,0	0,0	0,0	5,5	7,0	8,8	11,1	12,6	13,5	34,9
Mexico	12,9	13,9	15,0	16,2	17,1	18,2	18,7	19,7	20,7	21,7	25,0	30,6	37,1	51,8
Netherlands	9,2	12,6	20,5	26,3	46,0	49,6	51,2	52,7	61,8	65,9	76,8	98,6	150,4	345,4
Norway	0,0	0,0	0,0	6,4	6,6	6,9	7,3	7,7	8,0	8,3	8,7	9,1	9,5	10,0
Portugal	0,9	1,1	1,3	1,7	2,1	2,7	3,0	3,4	17,9	68,0	102,2	130,8	143,6	209,7
Spain	0,0	0,0	0,0	0,0	11,5	24,1	50,4	154,3	739,2	3635,1	3698,1	4109,7	4471,9	4706,1
Sweden	2,5	2,7	2,9	3,2	3,4	3,7	4,0	4,3	4,6	4,8	8,8	11,5	15,9	24,3
Switzerland	13,4	15,3	17,6	19,5	21,0	23,1	27,1	29,7	36,2	47,9	73,6	110,9	211,1	437,0
Turkey	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	8,5
UK	0,9	1,7	2,5	3,9	5,7	8,0	10,7	14,1	17,9	22,3	25,8	69,6	975,8	1900,8
USA	0,0	0,0	0,0	28,0	73,0	131,0	172,0	275,0	427,0	738,0	1172,0	2022,0	3910,0	7272,0
Total IEA PVPS	**335,5**	**551,8**	**818,0**	**1196,0**	**1668,4**	**2756,5**	**4096,7**	**5523,5**	**8002,6**	**14342,0**	**21169,8**	**35822,2**	**63881,1**	**89207,7**
Other Major Countries	0,0	1,4	1,4	3,0	4,2	5,8	7,0	9,1	13,4	86,3	526,3	2342,6	3382,4	10054,7
Total	**335,5**	**553,2**	**819,4**	**1199,0**	**1672,6**	**2762,2**	**4103,7**	**5532,5**	**8016,1**	**14428,3**	**21696,1**	**38164,8**	**67263,5**	**99262,4**



Glass/Glass Crystalline Silicon BIPV Installation, ISSOL Headquarters, Dison, Belgium

CHAPTER 3 - Policy Framework

PV development in the last ten years has been powered by the deployment of support policies, aiming at reducing the gap between PV's cost of electricity and the price of conventional electricity sources. These support schemes took various forms depending on the local specificities and evolved to cope with unexpected market evolution or policy changes.

In 2012, the price of PV systems, as we have seen, and accordingly the cost of producing electricity from PV (LCOE) had dropped to levels that are in some countries close or even below the retail price of electricity. In several countries, the so-called "fuel parity" has been reached: This means that producing electricity with a PV system is now in some cases cheaper than producing it with a diesel-generator.

But PV systems are not yet fully competitive and the development of PV still requires adequate support schemes and ad hoc policies with regard to electricity grids connections, building use and many others. This chapter focuses on existing policies and how they have contributed to develop PV. It pinpoints, as well, local improvements and examines how the PV market reacted to these changes.

Market Drivers in 2012

Figure 9 below shows that around 12% of the world PV market has been driven by self-consumption or the sole competitiveness of PV installations in 2012.

A large part of the market remains dominated by feed-in tariffs schemes while subsidies aiming at reducing the upfront investment represent around 25% of the incentives. With some success in the Netherlands, Denmark and the USA, net-metering was the main incentive in 2012 for 2% of the world market. It can be argued that net-metering exists in other countries, such as Belgium where net-metered installations in 2012 were around 500 MW but this is not the main investment driver in that country. This situation could change in 2013, especially in Italy.

Historically the dominance of feed-in tariffs and direct subsidies is similar but even more visible on figure 10.

Incentives can be granted by a wide variety of authorities or sometimes by utilities themselves. They can be unique or add up to each other. Their lifetime is in general quite short, with frequent policy changes, at least to adapt the financial parameters. Next to central governments, regional states or provinces can propose either the main incentive or some additional ones. Municipalities are more and more involved in renewable energy development and can offer additional advantages.

In some cases, utilities are proposing specific deployment schemes to their own customers, in general in the absence of national or local incentives.

Feed-in Tariffs

The concept of FiTs is quite simple: Electricity produced by the PV system and injected into the grid is paid at a predefined price and guaranteed during a fixed period. In theory, the price could be indexed on the inflation rate but this is rarely the case. This assumes that a PV system produces electricity for exporting into the grid rather than for local consumption. The most successful examples of FiT systems can be found in Germany, Italy and Japan, to mention a few.

Levy on Electricity Consumers or Tax Payers Money

The cost of the FiT can be supported through taxpayers money or, and this is the most common case, at least in Europe, through a specific levy on the electricity bill (Austria, Germany, France, Italy etc.). This levy is then paid by all electricity consumers in the same way, even if some countries, Germany for instance, have exempted some large industrial electricity consumers for competitiveness reasons. The amount of cash available per year can be limited and in that case, a first-in first-served principle is applied (Austria, Switzerland). Most countries didn't impose a cap on FiT expenditures, which led to fast market development in Germany, Italy, Spain and many others.

When the budget available for the FiT payments is not limited, market regulation must come from another control measure: It is assumed that most market booms in countries with unlimited FiT schemes were caused by an imbalance between the level of the tariffs and the declining cost of PV systems. With the rapid price decrease of PV systems in the last years, the profitability of PV investments grew very fast when the level of the FiT wasn't adapted fast enough. This situation caused the market boom in Spain in 2008, in Czech Republic in 2010, in Italy in 2011 and in many other countries.

National or Local

Depending on the country specifics, FiT can be defined at national level (Spain, Germany, Japan, etc.), at a regional level (Australia, Canada) with some regions opting for and others not, or with different characteristics. In 2011, the French FiT law introduced a geographical parameter in the FiT level, in order to compensate for the difference of solar resource in its regions: Up to 20% more was paid for northern installations.

FiT can also be granted by utilities themselves (Sweden, Switzerland), outside of the policy framework.

Figure 9: Market Incentives in 2012

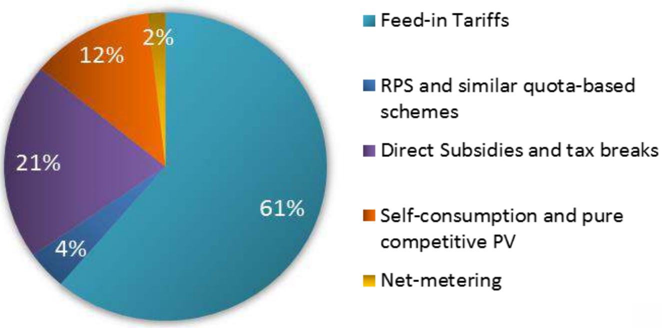
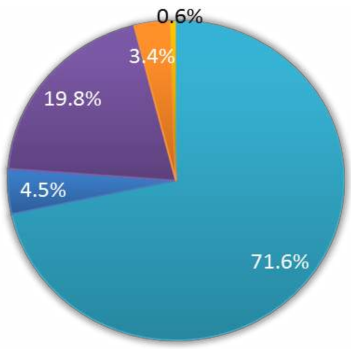


Figure 10: Historical Market Incentives



Market Control Systems

The "corridor" principle has been experimented in Germany since 2011 and will most probably become effective in 2013: The level of the FiT can be adapted on a monthly basis in order to reduce the profitability of PV investments if during a reference period (one year), the market has grown faster than the target decided by the government. The first attempt was hardly successful in Germany, with long delays between the FiT updates that allowed PV investment to remain highly profitable during several months, leading for instance to the tremendous December 2011 market boom where 3 GW were installed in Germany.

In the last years, other countries adopted the principle of decreasing FIT levels over time, with sometimes (France, Italy) a clear pattern for the future.

FIT remains a very simple instrument to develop PV, but it needs to be fine-tuned on a regular basis in order to avoid uncontrolled market development.

Calls for Tender

Calls for tender are another way to use FiT schemes with a financial cap. This system has been adopted in Spain and France for some market segments (especially large size PV installations). In order to get the FiT contract, a PV system owner must go through a tendering process. This process can be a competitive one (France) or simply an administrative procedure (Spain). It can be used to promote specific technologies (e.g. CPV systems in France) or impose additional regulations to PV system developers.

Additional Constraints

The ease of implementing FiT allows its use when PV is approaching competitiveness: Germany added a 90% cap in 2012 to the amount of electricity that could benefit from the FiT system, pushing for either selling the excess on the electricity market (at a quite low price, around 3-4 cUSD in 2012), or self-consumption. For systems where self-consumption is incentivized, a FiT can be used for the excess electricity not consumed locally and injected into the grid. This was done in Italy in the first "Scambio Sul Posto" system, a complex net-billing scheme.

In summary, FiT remains the most popular support scheme for all sizes of grid-tied PV systems; from small household rooftops applications to large utility scale PV systems.

Direct Capital Subsidies

PV is by nature a technology with limited maintenance costs, no fuel costs but a high upfront investment need. This has led some countries to put in place policies that reduce that up-front investment in order to incentivize PV. This took place over the years in Australia, Belgium, Japan and the USA. These subsidies are by nature part of the government expenditures and are limited by their capacity to free enough money. Off-grid applications can use such financing schemes in an easier way, than for instance FiT that are not adapted to off-grid PV development.

Renewable Portfolio Standards-RPS

The regulatory approach commonly referred to as "Renewable Portfolio Standard" (RPS) aims at promoting the development of renewable energy sources in competitive electricity markets. The authorities define a share of electricity to be produced by renewable sources that all utilities have to adopt, either by producing themselves or by buying specific certificates on the market. These certificates are sometimes called "green certificates" and allow renewable electricity producers to get a variable remuneration for their electricity, based on the market price of these certificates. This system exists under various forms. In the USA, some states have defined regulatory targets for RES, in some cases with PV set-asides. In Belgium's regions and Korea, PV receives a specific number of these green certificates for each MWh produced. A multiplier is used for PV, depending on the segment and size in order to differentiate the technology from other renewables. Korea, which used to incentivize PV through a FiT system moved to a RPS system in 2012 with a defined quota for PV installations. In Belgium, all three regions are using a RPS system that comes in addition to other schemes such as net-metering and in the past, direct capital subsidies and tax credits. The region of Brussels has introduced a specific correction factor that adapts the number of certificates in order to always bring the same financial return (7%).

Since 2010, the European Union lives under a directive (law) that imposes on all European countries to produce a certain percentage of their energy consumption with renewable energy sources. This directive, sometimes known as the 20-20-20 (20% RES, 20% less Green House Gases and 20% energy efficiency) translates into a target of around 35% of electricity coming from RES sources in 2020, but with differentiated targets for all member states. This overarching directive doesn't impose utilities to meet these targets directly but allows European countries to decide on the best way to implement the directive and reach the target. This explains the variety of schemes existing in Europe and the very different official targets that have been defined for PV, depending on the country. For instance, Germany alone targets 52 GW of PV installations in 2020.

Tax Credits

Tax credits can be considered in the same way as direct subsidies since they allow reducing the upfront PV investment. Tax credits have been used in a large variety of countries, ranging from Canada, USA to Belgium (until 2010), Switzerland, France, Japan, Netherlands and others. They highly depend on the government budgets, and are highly sensitive to the political environment, as the USA political debate has shown for wind tax credits in 2012.

Sustainable Building Requirements

With around 70% of PV installations occurring on buildings, the building sector has a major role to play in PV development. Sustainable building regulations could become a major incentive to deploy PV in countries where the competitiveness of PV is close. These regulations include requirements for new building developments (residential and commercial) and also, in some cases on properties for sale. PV may be included in a suite of options for reducing the energy footprint of the building or specifically mandated as an inclusion in the building development.

In Korea, the NRE Mandatory Use for Public Buildings Programme imposes on new public institution buildings with floor areas exceeding 1 000 square meters to source more than 10% of their energy consumption from new and renewable sources. In Denmark, the national building code has integrated PV as a way to reduce the energy footprint. Spain used to have some specific regulations but they never really succeeded in developing the PV market.

Two concepts should be distinguished here:

- Near Zero Energy Buildings (reduced energy consumption but still a negative balance);
- Positive Energy Buildings (buildings producing more energy than what they consume).

These concepts will influence the use of PV systems on building in a progressive way, once the competitiveness of PV will have improved.

Electricity Compensation Schemes

With 70% of the world PV market concentrated on rooftops, it seems logical that a part of the PV future will come from its deployment on buildings, in order to provide electricity locally. The declining cost of PV electricity puts it in direct competition with retail electricity provided by utilities through the grid and several countries have already adopted schemes allowing local consumption of electricity. These schemes are often referred to as self-consumption or net-metering schemes.

These schemes simply allow self-produced electricity to reduce the electricity bill of the PV system owner, on site or even between distant sites (Mexico). Various schemes exist that allow compensating electricity consumption and the PV electricity production, some compensate real energy flows, while others are compensating financial flows. While details may vary, the bases are similar.

Self-Consumption

Pure self-consumption exists in Germany: For instance, electricity from a PV system can be consumed by the PV system owner, reducing the electricity bill. The excess electricity can then benefit from the FiT system. Until 2012, Germany incentivized self-consumption by granting a bonus above the retail price of electricity. This bonus was increased once the threshold of 30% of self-consumed PV electricity was passed. With the decline of FiT levels, these are now below the price of retail electricity and the bonus has disappeared.

Net-Metering

Traditional self-consumption systems assume that the electricity produced by PV should be consumed immediately or within a 15 minutes timeframe in order to be compensated. Net-metering system allows such compensation to occur during a longer period of time, ranging from one month to several years, sometimes with the ability to transfer the surplus of consumption or production to the next month(s). This system exists in several countries and has led to some rapid market development in 2012 in Denmark and The Netherlands. In Belgium, the system exists for PV installations below 10 kW. In Sweden, some utilities allow net-metering while in the USA, several states have implemented net-metering policies.

Other Direct Compensation Schemes

While the self-consumption and net-metering schemes are based on an energy compensation of electricity flows, other systems exist: Italy, through its “Scambio Sul Posto” attributes different prices to consumed and produced electricity and allows a financial compensation with additional features (guaranteed export price for instance). In Israel, the net-billing system is working on a similar basis.

Grid Costs and Taxes

In 2012, the opposition from utilities and in some case grid operators (in countries where the grid operator and the electricity producers and retailers are unbundled as in Europe) grew significantly against net-metering schemes. While some argue that the benefits of PV for the grid and the utilities cover the additional costs, others are pledging in the opposition direction. In Belgium, the region of Flanders introduced a specific grid tax for PV system owners in order to maintain the level of financing of grid operators and the region of Wallonia was expected to do the same. In general, several regulators in Europe are expected to introduce capacity-based tariffs rather than energy-based tariffs for grid costs. This could change the landscape in which PV is playing for rooftop applications and delay its competitiveness in some countries.

Market Based Incentives

Most countries analyzed here have a functional electricity market where at least a part of the electricity consumed in the country is traded at prices defined by the laws of supply and demand of electricity. In order to further integrate PV into the electricity system, Germany set the so-called “market integration model” in 2012.

A new limitation at 90% (for systems between 10kW and 1 MW) of the amount of PV electricity that can benefit from the FiT scheme has been introduced in Germany in 2012. It has pushed PV system owners to sell the remaining PV electricity on the market. This can be done at a fixed monthly price with a premium (This average market value was in 2012 at 4,465 cEUR/ kWh, including 1,2 cEUR of management premium that goes down in 2013). In addition, the German law allows selling PV electricity directly on the market, with variable, market-based prices, the same management premium and an additional premium to cover the difference with FiT levels, with the possibility to go back and forth between the FiT scheme and the market. At the end of 2012, less than 3 GW of PV (out of 32 GW installed) were traded on a regular basis on the electricity market.

Market premiums can use existing financial instruments: the current project in the UK to replace the ROC system by a market-based model could introduce a variable premium above the wholesale market price through Contract for Difference products (CfD). They would have the advantage of fixing the revenues of large PV system owners.

Administrative and Legal Costs

Financial support schemes haven’t always succeeded in starting the deployment of PV in a country. Several examples of well-designed feed-in tariff systems have been proven unsuccessful because of inadequate and costly administrative barriers. Progress has been noted in most countries in the last years, with a streamlining of permit procedures, with various outcomes. The lead time could not only be an obstacle to fast PV development but also a risk of too high incentives, kept at a high level to compensate for legal and administrative costs.

Grid Integration Policies

With the share of PV electricity growing in the electricity system of several countries, the question of the integration to the electricity grid became more acute. At the European level, 2012 saw the continuation of the revision of the grid codes.

In China, the adequacy of the grid remains one important question and could lead to favor more the development of decentralized PV in the future rather than large utility-scale power plants.

In addition, the development of net-metering and self-consumption measures has led some countries to start revising their grid costs policies: Belgium and Bulgaria are clear examples of such countries.

Grid integration policies will become an important subject in the coming years, with the need to regulate PV installations in densely equipped areas.

Budgets for PV Deployment

Budgets for PV deployment policies can be found in detail in several National Survey Reports of IEA PVPS reporting countries.

The Cost of Support Schemes and Escalating Bills: Myth or Reality?

Growing discontent towards the historical cost of support schemes grew in 2012 in several countries, pushing governments to either reduce the support for PV deployment or to opt for retroactive changes. Australia, Germany, Italy, Belgium and Spain are some of the countries where such events occurred and the debate will go further in 2013. In Spain, the electricity tariff deficit (the difference between the retail price and electricity and its real cost) that is paid by taxpayers, reached a high level that forced the government to change retroactively some characteristics of the FiT schemes granted to existing PV plants. In Belgium, and also outside the IEA PVPS network in Bulgaria and Czech Republic, retroactive measures have been taken or discussed and could weaken the investor's confidence in PV.

In Italy, the total annual cost of FiT being paid to existing systems had reached more than 6 billion EUR at the end of 2012 and was planned to be stopped in 2013 once the cost would reach 6,7 billion EUR. At the same time in Germany, the levy used to finance FiT schemes (not only for PV) reached more than 5 cEUR/kWh in 2013, increasing the price of electricity by more than 20% and creating an important debate in the German political arena.

Trends in PV Incentives

The variety of PV market segments was well managed through a limited set of adequate support measures until 2012. Most successful PV deployment policies based themselves on either feed-in tariff policies (most of the time without tendering process) or direct incentives (including tax breaks). Other support measures remained anecdotic in the PV development history.

With declining cost of PV electricity generation, the question of "alternative" support schemes has gained more importance is several countries. The emergence of schemes promoting the local consumption of PV electricity is now confirmed and some countries rely on these schemes only to ensure PV deployment.

Instead of national support schemes, several countries favor private contracts to purchase PV electricity (PPA) from utility-scale power plants, while in several European countries the same plants are being banned from official support schemes.

BIPV is losing ground, with few countries maintaining adequate support schemes to favor their development.

Policies targeting the entire electricity system remain marginal, with several countries running RPS systems but few with real PV obligations.

And finally, the arrival of local content policies in several countries seems to be an official answer to the local industry difficulties.

Recycling Policies

A modern and green industrial production of PV products requires sound environmental policies of the companies involved along the whole value chain. This includes the management of the end-of-life treatment. Further efforts have to be made to improve the environmental profile of PV by careful selection of materials, increase of lifetime, repair and recycling friendly designs, environmentally benign production and low energy consumption during manufacturing and installation.

Due to the long lifetime of PV products, there is a very long delay until the modules will become waste in 25 – 40 years. This is a big difference to the mature markets of other products such as cars or electronic equipment. In these cases, only moderate market changes can be observed and the amount of waste versus new products is more or less constant in the medium term. In contrast to this, PV products are still at the beginning of their usage and thus the waste amounts are about three orders of magnitude smaller than in other industrial waste streams.

Nevertheless, waste treatment companies look at PV waste as a new business case and have started to secure their shares in a future waste market. The average lifetime of PV modules can be expected to be more than 25 years. As a result, there is hardly any waste at present but an increasing amount of end-of-life modules and rejects from production can be expected after 2020 all around the world. The increasing amount of waste, the increasing number of module technologies (and materials) requires technical solutions for cost-effective recycling of all PV components.

Recycling

With respect to both environmental impacts and resource efficiency, recycling is the most sustainable way to manage end-of-life PV systems. Recycling leads to a reduction in waste and related emissions, and also contributes to energy savings and emissions reductions in production processes by displacing primary materials with reclaimed materials. Displacement is particularly significant for raw materials with high impurities (e.g., semiconductor material) which often require energy intensive pre-treatment and for glass production where the carbon content of primary materials is released as CO_2 emissions in the melting process. Recycling is also an important strategy for long-term management of resource-constrained metals in PV. The PV recycling industry is expected to scale significantly over the next 10-15 years as annual waste generated by end-of-life PV modules is predicted to increase to over 1 million tons by 2035 (GlobalData, 2012).

WEEE

Future PV recycling trends can be examined by considering trends in electronic waste regulation. The European Union (EU) has mandated the recycling of waste electrical and electronic equipment since 2003, and end-of-life collection and recycling of PV modules has recently been included within the scope of the recast WEEE Directive (European Parliament and the Council of the European Union, 2012). Whereas the text of the Directive depicts a mass-based recovery quota which could be obtained by recycling of PV module glass and aluminum frames only, the European Commission also clearly saw the need to develop high value recycling standards (which can include recycling of PV semiconductor material) and mandated the European Standardization Organization CENELEC to develop these standards (European Commission, 2013). High value recycling is necessary for maximizing resource recovery and diverting metals from disposal and should be encouraged by future legislation setting more ambitious targets. PV modules are currently category 4 equipment of WEEE but a separate collection should be done, to avoid mixing with other e-wastes that require different recycling processes. The use of best available technologies, transparent monitoring and reporting systems and the preservation of any valuable material in the modules should be favored. This can encourage early investments in further research and certified industrial recycling plants optimized for PV products.

Tailor-made BIPV modules, ISSOL, Belgium

Recycling Going Global

While PV installations have been historically concentrated in the EU, PV deployment is globalizing beyond the EU into emerging markets where a combination of high solar irradiation and unmet and growing demand for electricity can create economically sustainable markets for PV. In these new markets, end-of-life collection and recycling may be achieved voluntarily through PV manufacturers or third party services, or may be mandated in future WEEE-type regulations or through project decommissioning requirements.

Bulk items in PV systems such as mounting steel, copper in cables, and aluminum frames are easily removed and recycled. PV module recycling technologies are also commercially available and consist of two primary steps. After the initial removal of bulk items, physical treatment crushes the module to small pieces, and chemical treatment separates semiconductor and plastics from glass, producing clean glass, plastics, semiconductor material, and residual metals as outputs. Up to 95% of the materials used in these modules can be recovered for the use in new materials.

BIPV systems with monocrystalline cells, 20 kW, Bolzano, Italy, courtesy of GSE

Today the waste amounts are sufficient to start with a take back and recycling system to gain experience and adjust the system to its growing demands. Possible recycling routes should consider the changes in cell or module technologies. They will have to recover valuable materials and deal with some hazardous materials.

BIPV system with monocrystalline cells, 8 kW, Roma, Italy, courtesy of GSE

Table 6: Overview of Support Schemes in Selected IEA PVPS Countries

	AUS	AUT	BEL	CAN	CHI	DEN	FRA	GER	ISR	ITA	JPN	KOR	MYS	NLD	SWE	CHE	TUR	GBR	USA
Highest Feed-in tariffs levels (USD/kWh)	0,45	0,35		0,55	0,16		0,44	0,20	+	0,27	0,53	-	0,40		L	0,36	0,10	0,22	+
Lowest Feed-in tariffs levels (USD/kWh)	0,08	0,24		0,35	0,12		0,11	0,14		0,14	0,43					0,19		0,10	
Indicate household retail electricity prices (USD/kWh)	0,27	0,26	0,29	0,18	0,07 / 0,10	0,39	0,18	0,36	0,13	0,22	0,36	0,16 / 0,61	0,07 / 0,15	0,28	0,27	0,15 / 0,27	0,19	0,23	0,08 / 0,17
Direct capital subsidies		R	R		+		L	+		+	+	+		+	+	R			+
Green electricity schemes	+	+						+		+	-			+		+			+
PV-specific green electricity schemes		+														+			+
Renewable Portfolio Standards	+		+	R							+	+			+	U		+	+
PV special treatment in RPS			+									+						+	+
Financing schemes for PV / Investment Fund	+			+				+			+			+					+
Tax credits			+	+			+			+	+		+	+		+	+	+	+
Net-metering / net-billing / self-consumption incentives	+	U	+	+	+	+		+	*	+	+			+	U	U	+	+	+
Commercial bank activities	+		+	+	+	+		+	+		+			+					+
Electricity utility activities	+			+		+	+	+			+	+		+	+	+			+
Sustainable building requirements	+			+	+	+	+					+		+		+			+

Notes
- U — Some utilities have decided such measures
- R — Such programmes have been implemented at regional level
- L — Such Programmes have been implemented at local level (municipalities)
- * — This support scheme is starting in 2013
- + — This support schemes has been used in 2012
- - — This support schemes has been canceled in 2012

4

NREL, Solar Junction: photolithography tool used to manufacture concentrator cells

CHAPTER 4 – Trends in the PV Industry

This section provides a brief overview of the industry involved in the production of PV materials (feedstock, ingots, blocks/bricks and wafers), PV cells, PV modules and balance-of-system (BOS) components (inverters, mounting structures, charge regulators, storage batteries, appliances, etc.) during 2012. Refer to the relevant National Survey Reports for a more detailed account of PV production in each IEA PVPS member country.

A national overview of PV material production and cell and module manufacturing in the IEA PVPS countries during 2012 is presented in the table 7 below and is directly based on the information provided in the national survey reports.

Although a number of IEA PVPS countries are reporting on production of feedstock, ingots and wafers, cells and modules, the picture from the national survey reports of the PV industry supply chain is by no means complete and consequently these data are provided more as background information.

The year 2012 was another difficult year for the PV industry. The total demand in 2012 could not keep the growth rate of the past years and the PV industry faced a zero growth for the first time in the 2000s. While the European PV market, which had long driven the expansion of the global PV market, experienced negative growth in 2012, the Asian PV markets such as China, Japan and India and the US PV market grew in 2012. The demand of these regions made up for the decline in the European market and the global PV market eventually managed to keep the level of the previous year. In addition to the slowed demand growth, continuous price reduction of PV cells and modules due to overcapacity also affected the industry. Numbers of PV manufacturers in IEA PVPS member countries shut down their business, filed for insolvency or made efforts on restructuring and reorganizing their business models. Even top 10 PV producers mainly consisting of Chinese manufacturers increased their deficits and faced tough business conditions. The producers of specialized equipment or materials such as chemical and gas, pastes and inks for cells, and encapsulation materials for PV modules were also affected by the difficult environment in 2012.

Table 7: Reported Production of PV Materials, Cells and Modules in 2012 in Selected IEA PVPS Countries

Country [1]	Solar PV Grade Si Feedstock Production (tons)	Production of Ingots (tons)	Production of Wafers (MW)	Cell Production (all types, MW)	Cell Production Capacity (MW/year)	Module production (MW)		
						Wafer Based (sc-Si & mc-Si)	Thin Film (a-Si & other)	Module Production Capacity (all types, MW/year)
Australia						1,3		60
Austria						>70,7		>234
Canada	NA					460		976
China	71 000	-	28 000	21 000	> 40 000	23 000		> 40 000
Denmark						10		23
France	-	-	-	~50	115	300	>1	750 [2]
Italy				20	40	397		610
Japan	6 102	2 709	800	2 286	> 4 000	1 595	691	> 4 300
Korea	40 000		1 800	1 000	1 490	1 700		2 670
Malaysia			300	1305	2 705	-	-	1 859
Netherlands					135			
Norway	900		200					
Sweden					35	222,5		222,5
Switzerland		900 [3]	approx. 120 [3]			~ 5 - 10		NA
USA	48 500		200	775	675	670	275	2 000

Notes:
(1) Although a number of IEA PVPS countries are reporting on production of feedstock, ingots and wafers, cells and modules, the picture from the national survey reports of the PV industry supply chain is by no means complete and consequently these data are provided more as background information.
(2) Estimation
(3) Including only crystalline silicon based modules

Feedstock, Ingots and Wafers (Upstream Products)

Wafer based crystalline silicon remains the dominant technology for making PV cells and the discussion in this section focuses on the wafer-based production pathway. Although some IEA PVPS countries reported on production of feedstock, ingots and wafers, the pictures from the national survey reports of these sections of the PV industry supply chain are not complete and consequently this section provides more background information.

Since January 2011 when the spot price was around 70 - 80 USD/kg, the polysilicon price dropped by more than 70% and the downward trends continued throughout 2012. The spot price of polysilicon decreased from about from 30 - 35 USD/kg in January 2012 to 15 - 21 USD/kg in December 2012. The decline is due to excess production capacity of polysilicon. Global total production capacity of polysilicon in 2012 was over 380 000 tons, almost double the actual global demand for crystalline silicon PV cells.

Most of major manufacturers adopt conventional technologies such as Siemens and FBR processes, which were used to supply silicon for the semiconductor industry. To address lowering price, major manufacturers are working on improvement of production efficiency. New technology such as metallurgical process has not yet become a major technology, mainly due to impurity issues. Some companies in IEA PVPS member countries that worked on new process closed their plant or exited from the business because of the overcapacity in 2012.

In 2012, polysilicon for PV cells was mainly manufactured in China, the USA, Korea, Germany and Japan. Canada and Norway also reported activities of polysilicon producers. China produced 71 000 tons of polysilicon, with 190 000 tons/year of production capacity in 2012. The production volume in China accounts for about 30% of global polysilicon production. Meanwhile, China imported 82 700 tons of polysilicon in 2012, a 28% increase from the previous year. Affected by the polysilicon price falling in the global market, most of Chinese enterprises with smaller production capacity have stopped production in 2012.

The USA has 79 500 tons/year of production capacity of polysilicon with three manufacturers and produced 48 500 tons. South Korea significantly increased polysilicon production in a short time and has more than 57 000 tons/year of production capacity. Total production in 2012 by Korean manufacturers reached 40 000 tons. Among four South Korean producers, OCI is the largest producer with 42 000 tons/year of capacity. The polysilicon production capacity of Germany in 2012 was more than 60 000 tons/year. In Japan, more than 6 000 tons of polysilicon was produced by Tokuyama and M.Setek in 2012.

Tokuyama plans to start its polysilicon plant in Malaysia. Affected by overcapacity, polysilicon producers suspended their capacity enhancement plans and some of them halted operation. Despite overcapacity, new plans for manufacturing polysilicon have continued to be reported but some potential entrants are expected not to advance their plans in consideration of the current business situation.

Ingots and Wafers

To make single-crystalline silicon ingots or multicrystalline silicon ingots, the basic input material is highly purified polysilicon. The ingots need to be cut into bricks or blocks and then sawn into thin wafers, whereas the ribbons are cut directly to wafers of desirable size. Conventional silicon ingots are of two types: Single-crystalline and multicrystalline. The first type, although with different specifications regarding purity and specific dopants, is also produced for microelectronics applications, while multicrystalline ingots are only used in the PV industry. Quasi-mono type that has fewer grain boundaries compared to multicrystalline that provides higher efficiency of PV cells was developed and commercialized by mainly Chinese producers but its share remained lower because performance of conventional multicrystalline wafers were improved. Ingot producers are in many cases also producers of wafers.

As in 2011, China is the world’s largest producer of solar wafers and reported 28 GW of wafer production, about a 16% increase from 2012. GCL-Poly Energy is the largest producer and manufactured 5 600 MW of wafers in 2012. Solar wafer production capacity in China is reported to be 50 GW/year. Other major wafer producing countries in IEA PVPS member countries are Germany, Korea, Malaysia, Japan, the USA, France and the UK. In Korea, seven companies were involved in the silicon ingot and wafer production. LG Siltron and Neosemitech stopped production, and Elpion was purchased by OCIS. The production capacity of ingots and wafers amounted to 2 920 and 2 590 MW, respectively. The wafer production was estimated to be about 1 800 MW in 2012. In Japan, M.SETEK produced 2 709 tons of single crystalline silicon ingots in 2012. Malaysia reported 300 MW of wafer production by MEMC.

The price decline of solar wafers continued in 2012 and the price dropped about 40% during 2012. As in 2011, a number of companies ended in making decisions to restructure their production frameworks, downsize or withdraw from the business. REC closed its Norwegian wafer manufacturing facilities and shifted its production to Singapore. Panasonic Corporation also decided to terminate wafer production in Oregon, USA, and to shift its production to Malaysia.

To address the cost pressures, some wafer manufacturers adopt new processes using diamond wire saws to improve production efficiency. Startup companies in the USA and Europe are developing new processes to manufacture wafers without conventional wire-sawing.

In non-IEA PVPS countries, Taiwan is a major producer of solar wafers with more than 6840 MW/year of production capacity in 2012.

CdTe Thin Film Utility-scale PV, 58MW, Copper Mountain ; Nevada, USA, Sempra Energy

PV Cell & Module Production

Total PV cell (crystalline silicon PV cell and thin-film PV cell) production in the IEA PVPS countries in 2012 is estimated to be 28,4 GW, about a 5% decrease from the previous year. As in 2011, China reported the largest production of PV cells. Total estimated production of PV cells in China is about 21 GW in 2012. While the growth rate from 2010 to 2011 was about 60%, figure 11 showed only a 5% growth from 2011. 5 companies among China's top 10 producers now have more than 2 GW of manufacturing capacity; Yingli Green Energy with 2,45 GW/year, JA Solar with 2,8 GW/year, Suntech Power with 2,4 GW/year, and Trina Solar with 2,45 GW/year. Other major IEA PVPS countries producing PV cells are Japan, Malaysia, Germany, the US, and South Korea. In 2012, the IEA PVPS countries accounted for 84% of the global solar cell production. Major non-IEA PVPS countries manufacturing solar cells are Taiwan, Philippines, Singapore and India. Major PV module producers in China started to procure solar cells made in Taiwan to avoid the antidumping duties for Chinese solar products in the USA and this brought a growth of solar cell production in Taiwan. 5,4 GW of solar cells were produced in Taiwan in 2012, a 25,6% increase from the previous year.

Figure 11: Share of PV Cells Production - 2012

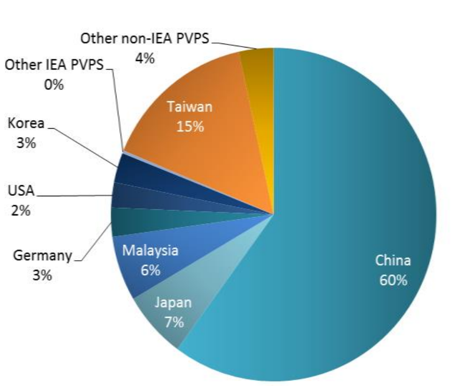


Figure 12: Share of PV Module Production - 2012

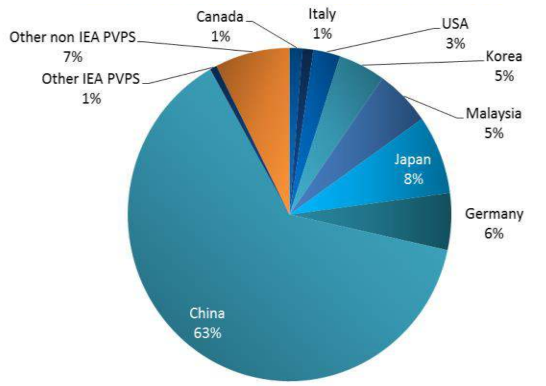


Figure 13: Yearly PV Production and Production Capacity in IEA PVPS and Main Other Manufacturing Countries (MW)

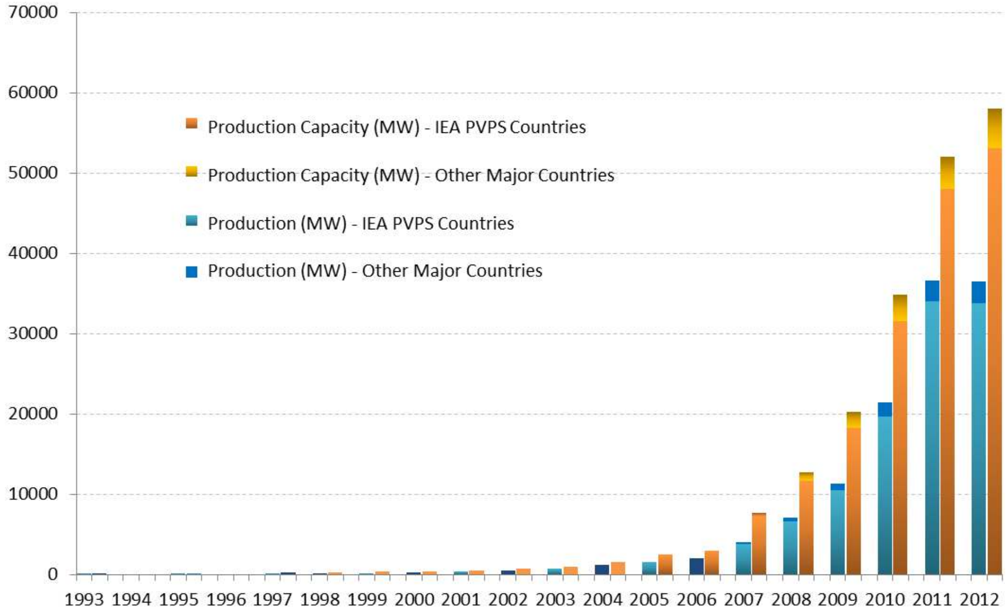
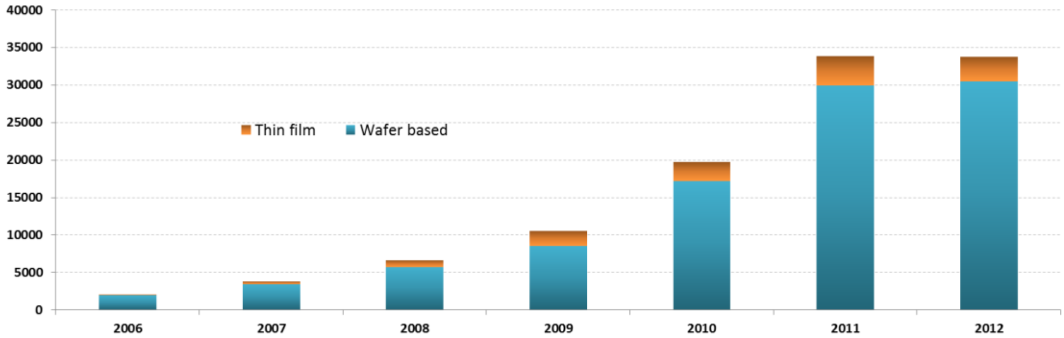


Figure 14: PV Module Production per Technology in IEA PVPS Countries – 2012 (MW)



The picture for PV module production is similar to that for cell production. A minimum of 33 GW of wafer based and thin-film PV modules were produced in the IEA PVPS countries in 2012. Figure 14 also shows a slight decrease from 2011 (34 GW). Again, the largest producer was China delivering about 23 GW with 40 GW/year of production capacity, contributing more than 60% of global production.

Other major IEA PVPS countries producing PV modules were Germany, Japan, Malaysia, Korea and the USA. Australia, Austria, Canada, Denmark, France, Italy and Sweden also reported module production.

Due to price competition, many PV module manufacturers with smaller production capacity mainly in Europe and the US halted the production or filed bankruptcy. Even long-term established players announced withdrawal from PV manufacturing or filed insolvency in 2012 (Q-Cells, Schott Solar, Bosch in Germany, a subsidiary of Suntech in China). It is notable that Canada increased production volume from 158 MW to 460 MW in 2012 with 976 MW/year of production capacity. Local content requirements under the FiT programme implemented in Ontario contributed to this growth (It is reported that Ontario states will modify the domestic content requirement following the World Trade Organization (WTO) decision).

In total, the IEA PVPS countries produced around 30 GW of wafer based modules and 3,3 GW of thin-film modules (thin film silicon, CdTe and CIGS) in 2012.

PV module production in IEA PVPS countries accounted for more than 90% of the modules produced globally. Figure 16 shows that the

Figure 15: Evolution of Cell Production in Selected Countries – 2008/2012 (MW)

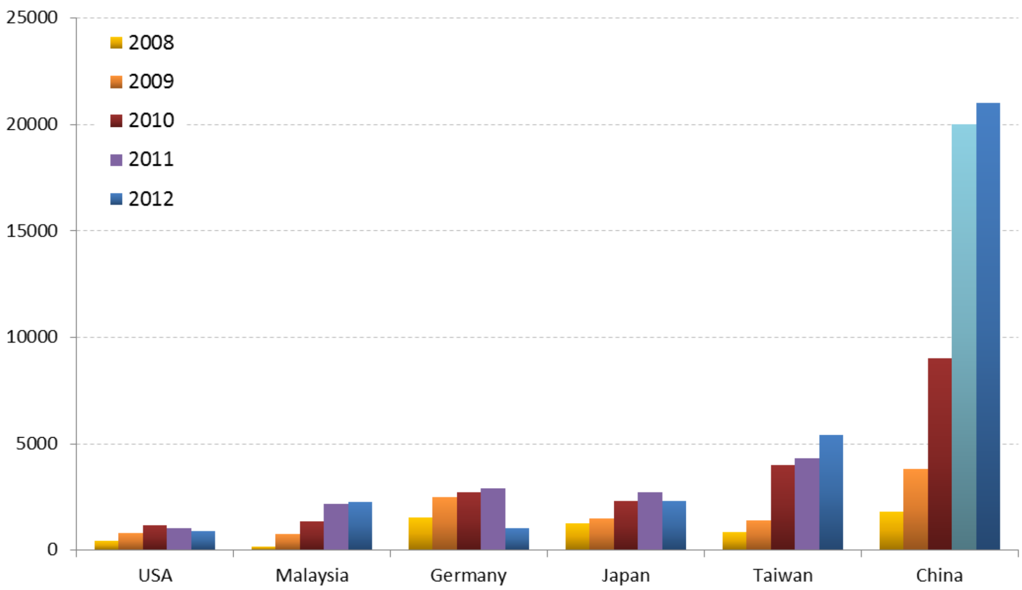
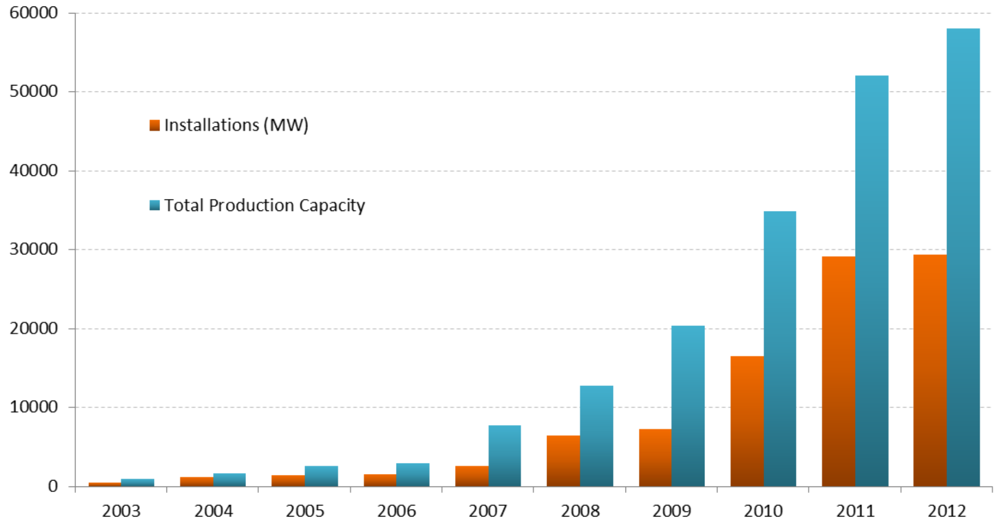


Figure 16: PV Installations and Production Capacities from 2003 to 2012 (MW)



estimated global production capacity reached close to 60 GW in 2012. Estimated utilization of global PV manufacturing capacity in 2012 was about 58%, an 11% decrease from the previous year.

Thin-film PV modules are mainly produced in Germany, Japan, Malaysia and the US. Among the US thin-film PV manufacturers, First Solar produced about 1,9 GW of CdTe PV modules in its factories in the USA, Germany (that closed end of 2012) and Malaysia in 2012. First Solar ranked as the largest thin-film PV module producer and the second largest solar cell producer in the world in 2012 production. The USA reported 275 MW of thin-film PV modules production in 2012. In Japan, a total of 690 MW of thin-film PV modules were produced by Sharp, Kaneka, Fuji Electric, Solar Frontier and Honda Soltec. Solar Frontier established 980 MW/year of manufacturing capacity and produced 550 MW of CIS PV modules in 2012. Thin-film PV manufacturers continued to be struggling in cost competition with crystalline silicon PV products. A number of companies with smaller production capacity and new entrants gave up their business and filed insolvency. Efforts on R&D and commercialization of CIGS PV modules are continuously implemented in a number of IEA PVPS member countries aiming at higher conversion efficiency and higher throughput.

In 2012, activities on concentrator PV (CPV) cell/modules are reported from several member countries. This technology is mainly based on specific PV cells using group III-V materials, such as GaAs, InP, etc. Germany, Australia, the USA, France and Spain are active in this area.

In 2012, PV product prices continued to drop because the continued imbalance between supply and demand. However, the market share of the top 10 PV producers showed the sign of the rationalization of excess production capacity. In 2005, the top 10 PV producers dominated more than 70% of the global market. Since then, the share of the top 10 PV companies decreased to around 40% in 2011. However, in 2012, the top 10 PV producers claimed 55% of the market: this illustrates clearly the concentration in the PV industry that is ongoing.

In this difficult business environment, trade frictions appeared in some regions. The Department of Commerce (DoC) of the USA concluded that Chinese exports to the USA were dumping prices and benefited from unfair subsidies. DoC imposed anti-dumping (AD) and anti-subsidy duties (CVD) on PV modules using solar cells made in China. The European Union (EU) also started investigation on dumping and unfair subsidies of Chinese PV manufacturers in September 2012. Following the investigation, the European Commission decided to impose provisional AD duties in June 2013. However, in August 2013, the European Commission and the Chinese PV industry reached an agreement on minimum prices and shipping volume for most Chinese PV manufacturers. Those that refused the agreement are submitted to a strong AD duty fee. In China, the Ministry of Commerce started antidumping investigation on polysilicon imported from the USA, Korea and Europe and decided to impose provisional AD on the USA and Korean made polysilicon. In India, the Ministry of Commerce started an investigation of dumping of PV modules made in the USA, China, Taiwan and Malaysia in January 2012.

This can be seen as an indirect consequence of the difficult business environment for PV. The stability of the market at a high level (29 GW) wasn't sufficient to absorb the production capacity that grew significantly in 2011 and 2012. The wave of bankruptcies that originated from PV module prices decline pushed several companies and administrations to look for a legal answer to these market imbalances

As well as the previous year, PV players have been focusing on differentiation of the products, cost structures, business models and customer portfolios to address lower margins. Consolidation and downstream integration by upstream sectors have been reported throughout 2012.

It is expected that shakeout and reorganization of the PV industry will continue in 2013 because excess production capacity is not yet resolved. It is considered that the era in which competitiveness was ensured by the economies of scale based on the capacity investment was over and reliability of the products, flexible manufacturing framework and earnings strength are more and more important for the PV players. Some expect a restart of the global PV market growth in 2013 and 2014, lowering pressure on the industry and allowing margins to increase to sustainable levels.

Balance of System Component Manufacturers and Suppliers

Balance of system (BOS) component manufacture and supply are important parts of the PV system value chain and are accounting for an increasing portion of system costs as PV module prices fall. Accordingly, the production of BOS products has become an important sector of the overall PV industry.

Inverter technology is currently the main focus of interest because the demand for grid-connected PV systems has been increasing. New grid codes require the active contribution of PV inverters to grid management and

Table 8: Evolution of Actual Module Production and Production Capacities (MW)

	Actual Production			Production Capacities		
	IEA PVPS	Non IEA PVPS	Total	IEA PVPS	Non IEA PVPS	Total
1993	52		**52**	80		**80**
1994						
1995	56		**56**	100		**100**
1996						
1997	100		**100**	200		**200**
1998	126		**126**	250		**250**
1999	169		**169**	350		**350**
2000	238		**238**	400		**400**
2001	319		**319**	525		**525**
2002	482		**482**	750		**750**
2003	667		**667**	950		**950**
2004	1160		**1160**	1600		**1600**
2005	1532		**1532**	2500		**2500**
2006	2068		**2068**	2900		**2900**
2007	3778	200	**3978**	7200	500	**7700**
2008	6600	450	**7050**	11700	1000	**12700**
2009	10511	750	**11261**	18300	2000	**20300**
2010	19700	1700	**21400**	31500	3300	**34800**
2011	34000	2600	**36600**	48000	4000	**52000**
2012	33787	**2700**	**36487**	53000	5000	**58000**

grid protection, thus new inverters are currently being developed with sophisticated control and interactive communications features. With the help of these functions, the PV plants can actively support grid management; for example by providing reactive power and other ancillary services.

In Europe, the major PV inverter companies are located in Germany, Spain, Austria, Switzerland, Denmark and Italy. European companies are extending their sales bases in the emerging markets. Outside Europe, activities in this field are reported from Japan, the USA, South Korea, Canada and China. In Canada, a number of inverter manufacturers started production to comply with the local content requirement implemented by the Ontario Province. China reported that there were more than 100 manufacturing companies of inverters. A number of inverter manufacturers completed the enhancement of production capacity following the growth of the PV market in the past several years and they were also suffering from the significant price reduction and tight competition. In the USA, Satcon, an established inverter manufacturer filed for insolvency in 2012. Consolidation of the inverter manufacturers has started against a backdrop of severe business conditions.

The products dedicated to the residential PV market have typical rated capacities ranging from 1 kW to 10 kW, and single (Europe) or split phase (the USA and Japan) grid-connection. For larger systems, PV inverters are usually installed in a 3-phase configuration with typical sizes of 10 to 250 kW. With the increasing number of utility-scale PV projects, larger inverters have been developed with rated capacities over 2 MW.

In the area of residential PV applications, inverters with storage batteries were commercialized aiming at developing the self-consumption market in Europe. While this market remains very small, the arrival of new financial incentives for storage systems in Germany in 2013 could trigger some limited market development.

In 2012 again, the micro-inverters market expanded. USA accounted for 72% of global micro-inverter shipments that were mainly used for residential applications.

Production of specialized components, such as tracking systems, PV connectors, DC switchgear and monitoring systems, is an important business for a number of large electric equipment manufacturers. Dedicated products and solutions are now also available in the utility-scale power range. Along with product development of Home Energy Management Systems (HEMS) and Building Energy Management Systems (BEMS), package products consisting of storage batteries, new and renewable energy equipment and PV systems are now on the rise.

Conclusions on Industry

In 2012, the imbalance between supply and demand was even more acute and the supply side of PV value chain faced the difficulty of working with extremely low or negative margins. Despites warning about the risk of market stagnation in 2012, many manufacturers decided to go forward with capacities expansions in 2012. The consequence was clear: The stagnating market was unable to absorb new production capacities and consequently, prices started to decrease. Moreover, price decreases require one to two years to create new markets for PV, which continued to push prices down.

Withdrawal, reorganization and closure of the business were increased in the upstream sector. Even established PV manufacturers filed for insolvency. Such evolution was visible in other countries, especially in Germany.

Due to the narrowing price gap with crystalline silicon PV modules, thin-film manufacturers faced intensified competition and several disappeared or merged in 2012.

Partnerships to enhance the PV business were accelerated in both the upstream and downstream industries.

However, while manufacturers suffered from lower margins, price reduction contributed to increase competitiveness of PV power against conventional energy and should trigger market development in several countries that will start to be visible in 2013 and later.

R&D Activities and Funding

The public budgets for research and development in 2012 in the IEA PVPS countries are outlined in the table 9. While several countries have reported a significant increase of expenditure in 2012 compared to 2011, most countries maintained the same scale of public budgets with some increases and some decreases. It is interesting to note that while a significant cost reduction of PV applications has been observed, grid-parity and sustainable markets are rapidly approaching and PV is now being regarded as a mainstream electricity supply option. Governments are clearly identifying the benefits of this technology's further development, better integration with existing energy systems and the benefits of innovations.

The most significant reporting countries in terms of R&D funding are the **USA**, **Germany**, **Korea**, **Japan**, **Australia**, **France** and **China**. Refer to National Survey Reports on the public website for a comprehensive summary of R&D activities in each of the countries. A brief overview of the R&D sector in key countries is presented below.

The **USA** is a clear leader in terms of R&D public funding for PV. DOE accelerates the research, development, and deployment of all solar energy technologies through its Solar Energy Technologies Programme Technologies Programme (SETP). In February 2011, DOE launched the SunShot Initiative, a programme focused on driving innovation to make solar energy systems cost-competitive with other forms of unsubsidized energy. To accomplish this, the DOE is supporting efforts by private companies, academia, and national laboratories to drive down the cost of solar electricity to about 0,06 USD/kWh. This, in turn, would enable solar-generated power to account for 15% to 18% of America's electricity generation by 2030. By funding selective RD&D concepts, the SunShot Initiative promotes a genuine transformation in the ways the USA generates, stores, and utilizes solar energy. SETP-funded research and development activities include the following: Demonstration and validation of new concepts in materials, processes, and device designs; RD&D of balance of system components; applied scientific research that provides the technical foundation for significant increases in solar PV cell efficiency, to enable commercial and near-commercial PV technologies to achieve installed system cost targets of 1 USD/W direct current by the end of the decade; and the Rooftop Solar Challenge, an initiative in which cities, states, and regions are awarded funding to develop innovative ways to drive measurable improvements in market conditions for rooftop PV across the US, with an emphasis on streamlined and standardized permitting and interconnection processes.

In **Germany**, R&D is conducted under the new 6th Programme on Energy Research 'Research for an Environmental Friendly, environmental friendly, reliable and Economically Feasible Energy Supply' which came into force in August 2011. Within this framework, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) and the Federal Ministry of Education and Research (BMBF) support R&D ranging from basic research to applied research on almost all aspects of PV. 2011 PV research funding showed a significant increase, particularly due to the implementation of the Photovoltaics Innovation Alliance, a joint programme of BMU and BMBF, launched in 2010 to promote a significant reduction of PV production costs. BMU research funding priorities are silicon wafer technology, thin-film technologies, systems engineering, alternative solar cell concepts and new research approaches (such as concentrator PV), as well as general issues such as building-integrated photovoltaics, recycling, and accompanying environmental research projects. Activities of the BMBF have

Table 9: R&D Funding in 2012

	R&D in USD	Increase / 2011
Austria	11,7 M (2011)	N/A
Australia	26,9 M	-14%
Denmark	4,32 M	-8%
Canada	12 M	21%
China	79 M	N/A
France	128 M (3-5 years)	15%
Germany	66 M	N/A
Italy	7,4 M	-8%
Japan	130 M	28%
Korea	118 M	26%
Netherlands	35 M	40%
Norway	14 M	N/A
Sweden	11,3 M	20%
USA	262 M	Stable

Warning: These indicative numbers should be considered with caution since they cover different realities depending on the country specific.

three focal points: Organic solar cells, thin-film solar cells (with emphasis on topics such as material sciences including nanotechnology, new experimental or analytical methods), and the cluster called 'Solarvalley Mitteldeutschland' in which most of the German PV industry participates.

Korea Energy Technology Evaluation and Planning (KETEP) has played a leading role in Korea's PV R&D programme since 2008. The R&D budget tripled in 2008 compared with 2007, showed a 20% increase in 2009, and continued to increase. In 2012, 70 projects are organized under four R&D sub-programmes with a budget of 77,2 Billion KRW. In 2012, numerous R&D projects have been initiated under the "Strategic & Commercialization Technology Develop- ment", "Basic & Innovative R&D" and "Short-term Core Technologies Develop- ment for Medium and Small industry". The sub-programme, Basic & Innovative R&D, is led by research institutes or universities, and the other three sub-programmes are led by industry. In 2012, a project focusing on BIPV development for commercial buildings with a design component was launched. Crystalline silicon takes the largest part of the R&D budget but CIGS, CPV, OPV, DSSC are also included. KETEP has also launched in 2012 a specific project called "Green, Energy- Independent Islands".

Japan reported various activities concerning PV R&D. The New Energy and Industrial Technology Development Organization (NEDO) conducted national PV R&D programmes, 'R&D on Innovative Solar Cells' and 'R&D for High Performance PV Generation System for the Future' with funding from the Ministry of Economy, Trade and Industry (METI).

In various programmes, projects focusing on crystalline silicon, thin-film silicon, thin-film CIGS, and organic thin-film solar cells have been conducted. R&D on CZTS solar cells is strengthened and the improvement of the reliability of PV modules, as well as the promotion of the cooperation with the foreign organizations towards certification and standardization of PV systems continued. The "Innovative Solar Cells" program, in cooperation of the EU, researches post-silicon solar cells for ultra-high efficiencies, novel thin multi-junction solar cells with a highly-ordered structure and thin-film full spectrum solar cells with low concentration ratios. OPV has its programme as well.

Development of grid control technologies such as forecasting of PV production, storage technologies and distribution grids controls is conducted as part of the improvement of electricity infrastructure.

The National Institute of Advanced Industrial Science and Technology (AIST) is preparing for the establishment of a new research center in Koriyama City, Fukushima Prefecture to mainly support renewable energy related industries in relation to the project for restoration from the Great East Japan Earthquake. The purpose of this center is the technological development and creation of industries associated with renewable energy and R&D activities in the field of renewable energy including PV.

Other programmes exist with the financing from the Ministry of Education, Culture, Sports, Science and Technology (MEXT).

In **Australia**, PV research, development and demonstration are supported at the national, as well as the state and territory levels. Research grants are available through the Australian Research Council and the Australian Solar Institute (ASI). ASI invested over 46 million AUD in 2012 on PV research ranging from new manufacturing techniques to hybrid system technologies and BIPV. From 2013, funding for technology development will be available from the Australian Renewable Energy Agency.

French R&D programmes are mostly funded by public agencies: ADEME (French Environment and Energy Management Agency), ANR (French National Research Agency) and OSEO (organisation providing financial support to French companies for start-up, innovation and development projects). Public research activities range from studies upstream of the value chain (ANR's PROGELEC programme) to finalised projects and industrial prototypes (ADEME's AMI PV, and OSEO's reindustrialisation support programme). These R&D projects are run on a public/private partnership basis.

Under the AMI PV programme, nine projects were selected, covering the following topics: The production of photovoltaic solar silicon by metallurgical route; the manufacturing of crystalline silicon ribbon; the manufacturing of thin-film CIGSSe modules by electro-deposition; the manufacturing of thin-film amorphous silicon modules and variants (including micromorph); the manufacturing of cells using group III-V materials for high-concentration photovoltaic applications; the development of concentrator photovoltaic (CPV) modules; and the development of encapsulation processes using advanced polymers. ANR is continuing its efforts in the PV sector with the PROGELEC 2011-2013 (renewable electricity production and management) programme. Five photovoltaic projects were selected in 2012, in addition to the five chosen in 2011.

OSEO through its industrial strategic innovation (ISI) business support programme, provides assistance for in- dustrial manufacturing pilot projects. In 2012 it supported two pilot production lines: one for n-type crystalline silicon cells, and the other for organic cells using inkjet printing technology.

The *Institut national de l'énergie solaire* (INES - French national solar energy institute) is currently undergoing rapid growth and is involved in a range of different public/private partnership projects. Public bodies CEA and CNRS, university laboratories and engineering schools are involved in research and innovation programmes. The *Institut photovoltaïque d'Île-de-France* (IPVF - Ile-de-France Photovoltaic Institute) includes several teams around IRDEP (EDF, CNRS) focusing their efforts on developing thin-film materials and new concepts.

In **Austria**, two research programmes ended in 2012: "New Energy 2020" and "Buildings of Tomorrow Plus". They both included a specific PV focus. They were replaced by a new programme called e!Mission. The improvement of cells efficiencies is still investigated, in parallel with nanostructured materials for flexible organic cells. The AIT Austrian Institute of Technology focuses on the electrical infrastructure (PV in smart electricity networks) and energy in the built environment (BIPV).

In **Belgium**, almost all PV technologies are studied: Organic, back-contact crystalline silicon, printed CIGS, CPV.

In **Italy**, ENEA is the main research organization focusing on PV, with a focus on high-efficiency crystalline silicon, copper oxide cells and concentrator technologies.

China reported various R&D activities on crystalline silicon solar cells, thin-films, CPV, power electronics, control, BoS, equipment and testing technologies. While the magnitude of the budget is estimated around 500 million RMB, China has been conducting PV R&D under the National High-tech R&D Programme (863 Programme) since 1986 and basic research related to PV under the National Basic Research Programme (also called the 973 Programme). The Ministry of Science and Technology (MoST) supports the key technologies in storage, transmission demonstrations of PV and wind power generation. Under China's 12th Five Year Plan (2011–2015) major R&D projects are planned to facilitate breakthroughs in all areas, to promote significant growth in PV power generation. Targets for PV cell development by 2015 are development of greater than 20% and 10% conversion efficiencies for crystalline silicon solar cells and silicon-based thin-film solar cells respectively, and also the commercialization of CIGS and CdTe thin-films.

Norway focuses mainly on the silicon value chain from feedstock to cells, but also fundamental material research and production processes. Six main R&D groups are active in the PV research in the country. Amongst them, the Norwegian "*Research Centre for Solar Cell Technology*" was established in 2009 until 2017 to support the development of the PV industry. Research on materials, processes and technology enabling the development of cost-competitive solar modules is its key focus.

Other projects are also planned in the areas of polysilicon production, devices, equipment, materials, components and systems. Demonstration of a 100 MW grid-connected PV power station,10 MW PV micro-grid and regional 10 MW building-related PV applications are also planned. In addition to these projects, the national 973 Programme will support R&D on the next generation of super-efficiency, new concept PV cells with 40% conversion efficiency.

The **European Commission** promotes PV research and development under the European Union's 7th Framework Programme (FP7). 2012 marked the sixth year of the FP7 that will operate until 2013 before being replaced by the new Horizon 2020 program. FP7 has a significantly increased budget compared to the previous framework programme but uncertainty remains on the future budget of its successor. Material development for longer-term applications, concentration PV and manufacturing process development have attracted most European funding in FP7. With the first five calls launched under the FP7, more than 172 Million EUR have already been invested.

Development of materials for longer-term applications, concentration PV and manufacturing process improvement have attracted considerable European funding. Furthermore, significant funding has been made available for thin-film technology.

Several countries have a dedicated research programme targeting PV technologies. In **Switzerland**, the programme targets basic research, applied research, product development, pilot and demonstration projects. **Canada** focuses on demonstration and field test projects focused on residential and commercial buildings, as well as small remote community-scale applications. Thin film solar cells are researched in **Switzerland**, in all fields of technology: Amorphous/micromorph and microcrystalline silicon, dye cells, compound semiconductors and organic cells. CIGS on plastic substrates is one of the technologies. **Canada** researches organic, dye cells, TF silicon, high-efficiency III-V multi-junctions, advanced crystalline silicon cells. In **China**, silicon based-TF, CIGS and CdTe are studied. Crystalline silicon cells are part of the research programme in Switzerland (high-efficiency heterojunction silicon cells). Building integration receives attention in **Switzerland** and **Canada** while some countries including Canada are focusing on smart net-zero energy buildings. In Israel, universities and research centers are working in almost of technology fields, from CPV to OPV, DSSC, thin-film and of crystalline silicon. Finally **Denmark** launched at the end of 2012 a small BIPV program.

Worker at a Thin Film PV Plant, NREL, Dennis Schroeder, Solar TAC, SunEdison, USA

CHAPTER 5 – PV and the Economy

Value for the Economy

The 2012 market stagnation, together with the price decline, caused the business value of PV to decrease in 2012 from around 110 Billion USD to 75 Billion USD.

The table 10 shows the estimated business value for PV in IEA PVPS reporting countries and the major markets. The value corresponds to the internal PV market in these countries, without taking imports and exports into account. For countries outside the IEA PVPS network or countries that didn't report a specific business value, this one is estimated based on the average PV system price.

Figure 17: Business Value of the PV Market Compared to GDP

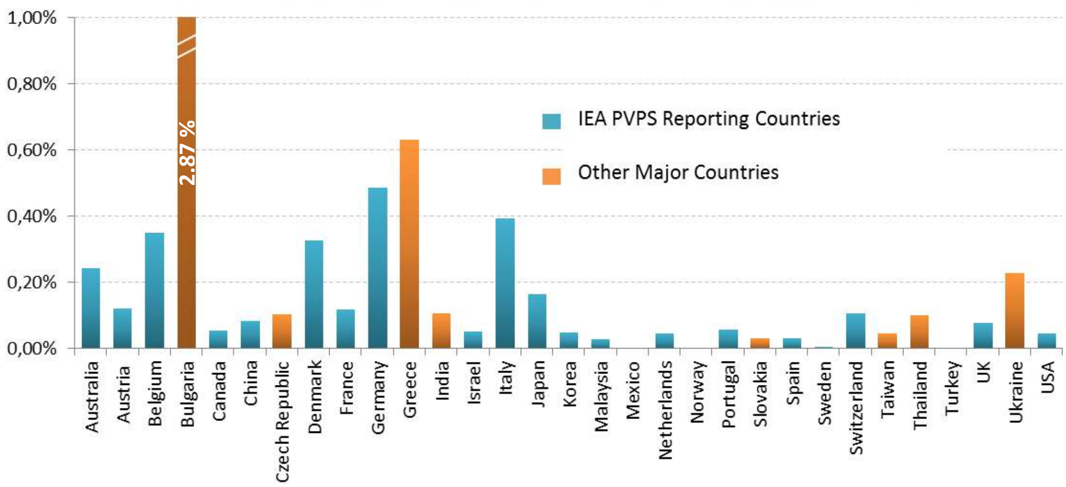


Table 10: Business Value of IEA PVPS PV Markets in 2012 (USD)

Germany	17 520
Japan	9 934
Italy	8 609
USA	6 652
China	6 146
Australia	3 335
France	3 238
UK	1 850
Belgium	1 800
Denmark	1 090
Canada	939
Switzerland	696
Korea	522
Austria	500
Spain	468
Netherlands	384
Portugal	132
Israel	121
Malaysia	81
Mexico	29
Sweden	25
Norway	8
Turkey	4

Industrial business value including exports and imports has not been considered in this table.

Some countries have benefited from exports that have increased the business value they obtained through the PV market while huge imports in other countries have had the opposite effect. Some countries could still be seen as net exporters, creating additional value next to their home PV market.

This is the case of Denmark, Norway, Sweden, Canada or Switzerland where 1,2 Billion CHF of exports compensated some 194 Million CHF of imports. In Norway, the value of the PV industry amounts of around 1,6 Billion NOK or 275 million USD. Other countries, such as Germany, France and Italy, with less industrial players and/or a huge PV market in 2012 reduced the business value of PV due to imports. The business value of PV should be compared to the GDP of each country. In most cases, the business value of PV represents less than 0,5% in the most developed PV countries. Bulgaria, with a major market development in 2012 reached the tremendous level of 2,87% of its GDP invested in PV in one single year.

Trends in Employment

Employment in the PV sector should be considered in various fields of activity: Research and development, manufacturing, but also deployment, maintenance and education.

Table 11 : Employment in IEA PVPS Countries

	Labour Places	Difference with 2011
Australia	11 600	9%
Austria	4 850	16%
Belgium	20 500	N/A
Canada	3 900	-27%
China	300 000	-40%
Denmark	7 050	N/A
France	18 000	-34%
Germany	100 000	-22%
Italy	16 500	-70%
Japan	47000	4%
Korea	11 500	Stable
Malaysia	7 262	-20%
Norway	500	Stable
Sweden	615	35%
Switzerland	8 600	-14%
USA	119 000	13%

Employment data for several countries are estimates. They comprises in general industrial and installation work forces.

PV labor places dropped from around 500 000 in 2011 to around 300 000 in China in 2012, the levels of 2009 and 2010. The consolidation of the industry in China explains this evolution. In most countries, this evolution is similar: The consolidation of the industry, together with market stagnation at the global level, has caused the employment in the PV sector to decrease in several countries. The market decline in Italy had huge effects on the employment, with few industrial jobs but numerous jobs linked to installations. In general, the evolution of employment is linked to the industry and market development, with important differences from one country to another due to the local specifics.

BIPV installation, ISSOL, Perpignan Train Station, France

CHAPTER 6 – Competitiveness of PV Electricity in 2012

For years, some in the PV industry claimed that reaching the so-called "grid parity" would unlock the development of PV without incentives. The grid parity has been reached in several countries and market segments but the achievement of competitiveness remains a challenge for the PV sector. In the last years, the understanding of the notion of competitiveness for PV systems has improved and in several countries, incentives and non-financial support schemes have been adapted to cope with the new reality of pre-competitive PV.

The fast price decline that PV experienced in the last years opens new possibilities to develop PV systems in some locations with limited or no financial incentives. But the road to the full and natural competitiveness of PV systems with conventional electricity sources depends on answering many questions and bringing innovative solutions to emerging challenges.

This section aims at defining where PV stands with regard to its own competitiveness, starting with a survey of system prices in IEA PVPS reporting countries. Given the number of parameters involved in competitiveness simulations, this chapter will mostly highlight the comparative situation in key countries.

System Prices

Reported prices for PV systems vary widely and depend on a variety of factors including system size, location, customer type, connection to an electricity grid, technical specification and the extent to which end-user prices reflect the real costs of all the components. For more detailed information, the reader is directed to each country's national survey report.

On average, system prices for the lowest price off-grid applications are more than double those for the lowest price grid-connected applications. This is attributed to the fact that off-grid systems require storage batteries and associated equipment.

Table 12 : Indicative Prices for Installed PV Systems in Selected IEA PVPS countries in 2012 (End of Year)

	Off-grid (EUR or USD per W)				Grid-connected (EUR or USD per W)			
	<1 kW		>1 kW		<10 kW		>10 kW	
	EUR	USD	EUR	USD	EUR	USD	EUR	USD
Australia	4,8-12,1	6,2-15,5	5,6-16,1	7,2-20,6	2,0-3,2	2,6-4,1	1,2-1,6	1,5-2,1
Austria	≤ 10	≤ 12,8	≤ 10	≤ 12,8	1,9 - 2,7	2,4 -3,5	< 1,9	< 2,4
Belgium					1,8 - 3,5	2,3 - 4,5	1,2 - 1,8	1,5 - 2,3
Canada			6,3	8,1	2,3 - 3,9	3,0 - 5,0	2,2 - 3,1	2,8 - 4,0
China							1,24	1,58
Denmark	2,0 - 4,0	2,6 - 5,2	4,0 - 7,4	5,2 - 9,5	2,0 - 4,0	2,6 - 6,0	1,3 - 4,7	1,7 - 6,0
France			15	19,2	3,7	4,7	1,6 - 2,0	2,1 - 2,6
Germany					1,4 - 2,4	1,8 - 3,1	1,3 - 1,6	1,7 - 2,1
Israel							2	2,6
Italy	3,1 - 5	3,8 - 6,4			2 - 2,8	2,6 - 3,6	1 - 2,6	1,3 - 3,3
Japan					4,6	5,9	4,3	5,5
Korea					2,1	1,7	2,7	2,1
Malaysia					2,3 - 3,1	2,9 -3,9	1,8 - 2,3	2,3 - 2,9
Netherlands					1,3 - 1,4	1,68 - 1,74	1,15 - 1,2	1,47 - 1,55
Norway	8,1 - 20	10,3 - 25,8			2,7 - 4,0	3,4 - 5,2	2,0 - 2,7	2,6 -3,4
Spain			4	5,2	2,5	3,2	2	2,6
Sweden	3	3,8			2,3 - 2,5	3,0 - 3,2	1,8	2,4
Switzerland	8,3 - 16,6	10,6 - 21,3	6,6 - 12,4	8,5 - 16,0	2,5 - 5,0	3,2 - 6,4	2,1 - 2,9	2,7 - 3,7
USA					4,15	5,31	2,5 - 3,8	3,2 - 4,9

Note : System Prices have been collected at national level and represent an average over market segments and technologies. Higher and lower prices have been reported in 2012 especially at the end of the year due to modules inventory sales at extremely low prices.

Additional information about the systems and prices reported for most countries can be found in the various national survey reports on the IEA PVPS website; excluding VAT and sales taxes. More expensive grid-connected system prices are often associated with roof integrated slates or tiles or one-off building integrated designs or single projects, and figures can also relate to a single project.

In 2012, the lowest system prices in the off-grid sector, irrespective of the type of application, typically ranged from about 2,6 USD/W to 20 USD/W. The large range of reported prices in the table 12 above is a function of country and project specific factors. In general, the price range decreased from the previous year.

The lowest achievable installed price of grid-connected systems in 2012 also varied between countries as shown above. The average price of these systems was around 2,8 USD/W, about 22% lower than the average 2011 price (3,6 USD/W). Prices as low as 1,6 USD/W were reported; typically prices were in the range of 2,4 USD/W to 3,7 USD/W. Large grid-connected installations can have either lower system prices depending on the economies of scale achieved, or higher system prices where the nature of the building integration and installation, degree of innovation, learning costs in project management and the price of custom-made modules may be considered as quite significant factors.

Figure 18: Evolution of PV Modules Prices in 3 Indicative Countries (normalized to 2001)

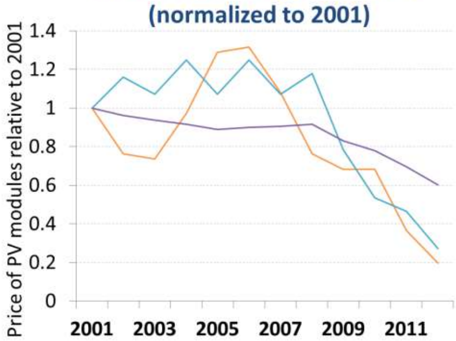


Table 13: Indicative Module Prices (in National Currency, EUR and USD per Watt) in Selected IEA PVPS Countries.

	Currency	National Currency	EUR	USD
Australia	AUD	0,9 - 1,8	0,72 - 1,45	0,93 - 1,86
Austria	EUR	0,8 - 3,8	0,8 - 3,8	1,0 - 4,9
Canada	CAD	1,15	0,9	1,15
China	CNY	4,5	0,56	0,71
Denmark	DKK	6-10,1	0,81 - 1,35	1,04 - 1,73
France	EUR	0,72	0,72	0,92
Germany	EUR	0,54 - 0,84	0,54 - 0,84	0,69 - 1,1
Israel	NIS	3,12 - 2,31	0,47 - 0,63	0,60 - 0,81
Italy	EUR	0,5 - 0,7	0,5 - 0,7	0,64 - 0,90
Japan	JPY	290	2,8	3,6
Korea	KRW	1 000	0,69	0,89
Malaysia	MYR	4	1,02	1,31
Netherlands	EUR	1,04	1,04	1,33
Spain	EUR	0,4 – 1,0	0,4 – 1,0	0,52 – 1,3
Sweden	SEK	7 - 16,1	1,04 - 1,84	1,33 - 2,36
Switzerland	CHF	0,85 - 1,30	0,71 - 1,10	0,90 - 1,38
USA	USD	0,76	0,59	0,76

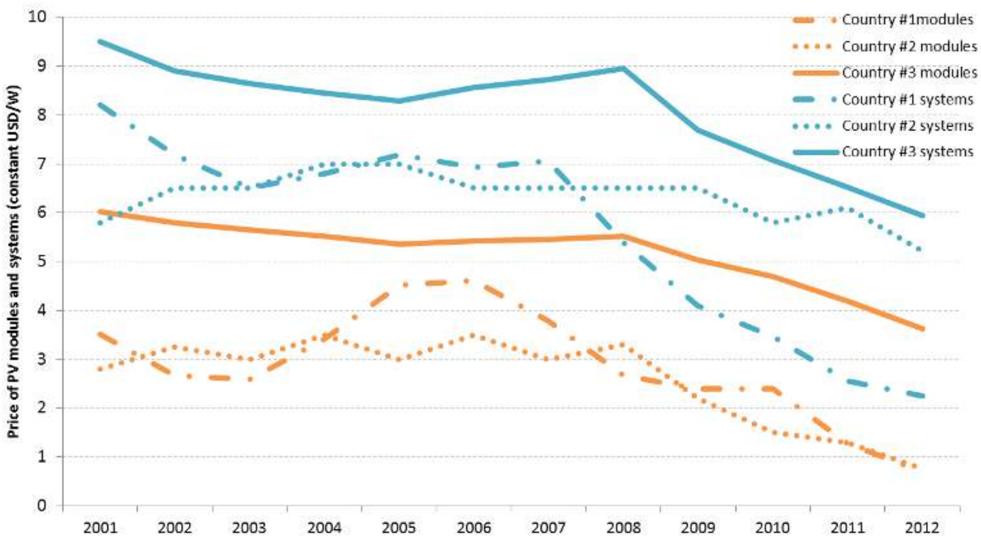
Note : Prices are averages considered during the year 2012 for different technologies and volumes. Lower and higher prices can heav been found on the market due to commercial actions.

On average, the price of PV modules in 2012 (shown in the table 13) accounted for approximately 43% of the lowest achievable prices that have been reported for grid-connected systems. In 2012, the average price of modules in the reporting countries was about 1,16 USD/W, a decrease of almost 15,9% compared to the corresponding figure for 2011 (1,38 USD/W), following a decrease of 50% in the previous year. Most reporting countries recorded lower module prices than in 2011. Eight countries reported module prices less than 1 USD/W; half of the lowest achievable prices fell below the range of 1,0 USD/W to 1,5 USD/W. Some countries reported at the end of 2012 modules prices below 0,6 USD/W raising questions about the profitability of companies selling them. Figure 18 shows the evolution of normalized prices for PV modules in selected key markets. Figure 19 shows the trends in actual prices of modules and systems in selected key markets.

In order to compete in the electricity sector, PV technologies need to provide electricity at a cost equal or below the cost of other technologies. Obviously, power generation technologies are providing electricity at different costs, depending on their nature, the cost of fuel, the cost of maintenance and the number of operating hours during which they are delivering electricity.

The competitiveness of PV can be defined simply as the moment when, in a given situation, PV can produce electricity at a cheaper price than other sources of electricity that could have delivered electricity at the same time. Therefore the competitiveness of a PV system is linked to the location, the technology, the cost of capital, and the cost of the PV system itself that highly depends on the na-

Figure 19: Evolution of Prices of PV Modules and Residential Systems in Selected Countries – Years 2001 to 2012 (USD/W)



ture of the installation and its size. But it will also depend on the environment in which the system will operate: Off-grid applications in competition with diesel-based generation won't be competitive at the same moment as a large utility-scale PV installation competing with the wholesale prices on electricity markets. The competitiveness of PV is connected to the kind of PV system and its environment.

Grid Parity

Grid Parity refers to the moment when PV can produce electricity (LCOE) at a price below the price of electricity. While this is valid for pure-players (the so-called "grid price" refers to the price of electricity on the market), this is based on two assumptions for *prosumers* (producers who are also consumers of electricity):

- That 100% of the PV electricity can be consumed locally (either in real time or through some compensation scheme such as net-metering);
- That all the components of the retail price of electricity can be compensated.

However, it is assumed that the level of self-consumption that can be achieved with a system that provides on a yearly basis the same amount of electricity as the local consumption, varies between 30% (residential applications) and 100% (for some industrial applications) depending on the country and the location.

Technical solutions will allow for increases in the self-consumption level (demand-side management, local storage, reduction of the PV system size, etc.).

If only a part of the electricity produced can be self-consumed, then the remaining part must be injected into the grid, and should generate revenues of the same order as any production of electricity. Today this is guaranteed for small size installations by the possibility of receiving a feed-in tariff for the injected electricity. Nevertheless, if we consider how PV could become competitive, this will imply defining a way to price that electricity so that smaller producers will receive fair revenues.

The second assumption implies that the full retail price of electricity could be compensated. The price paid by electricity consumers is composed in general of three main components:

- the procurement price of electricity on electricity markets plus the margins of the reseller;
- grid costs and fees, partially linked to the consumption partially fixed;
- taxes.

If the electricity procurement price can be obviously compensated, the two other components require considering the system impact of such a measure: The losses of taxes on one side and the lack of financing of distribution and transmission grids on the other one. While the debate on taxes can be simple, since PV installations are generating taxes as well, the one on grid financing is more complex. Even if self-consumed electricity could be fully compensated, alternative ways to finance the grid should be considered given the loss of revenues for grid operators.

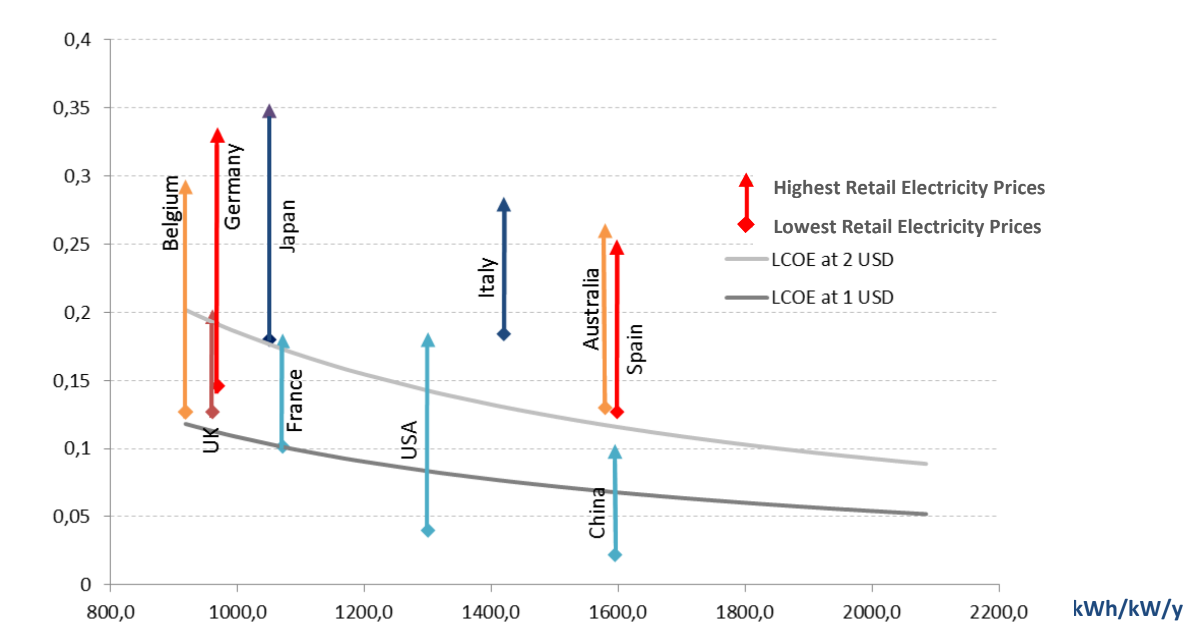
Competitiveness of PV Electricity with Wholesale Electricity Prices

In countries with an electricity market, wholesale electricity prices at the moment when PV produces are one benchmark of PV competitiveness. These prices depend on the market organization and the technology mix used to generate electricity. In order to be competitive with these prices, PV electricity will have to be generated at the lowest possible price. This will be achieved with large utility-scale PV installations that allow reaching the lowest system prices today with low maintenance costs and a low cost of capital. The influence of PV electricity on the market price is not yet precisely known and could represent an issue in the medium to long term.

Fuel-Parity and Off-Grid Systems

Off-grid systems including hybrid PV/diesel can be considered as competitive when PV electricity can provide electricity at a cheaper cost than the conventional generator. For some off-grid applications, the cost of the battery bank and the charge controller should be considered in the upfront and maintenance costs while a hybrid system will consider the cost of fuel saved by the PV system.

Figure 20: Grid Parity: retail Electricity Prices & PV LCOE



The point at which PV competitiveness will be reached for these hybrid systems takes into account fuel savings due to the reduction of operating hours of the generator. Fuel-parity refers to the moment in time when the installation of a PV system can be financed with fuel savings only. It is assumed that PV has reached fuel-parity based on fuel prices in numerous Sunbelt countries.

Other off-grid systems are often not replacing existing generation sources but providing electricity in places with no network and no or little use of diesel generators. They represent a completely new way to provide electricity to hundreds of millions of people all over the world.

Comments on Grid Parity and Competitiveness

Finally, the concept of Grid Parity remains an interesting benchmark but shouldn't be considered as the moment when PV is competitive by itself in a given environment. On the contrary, it shows how complex the notion of competitiveness can be and how it should be treated with caution. Countries that are approaching competitiveness are experiencing such complexity: Germany, Italy or Denmark for instance have retail electricity prices that are above the LCOE of a PV system. But considering the self-consumption and grid constraints, they haven't reached competitiveness yet. For these reasons, the concept of Grid Parity should be used with caution and should take into consideration all necessary parameters. Finally, PV remains an investment like all others. The relatively high level of certainty during a long period of time shouldn't hide the possible failures and incidents. Hedging such risks has a cost in terms of insurance and the expected return on investment should establish itself at a level that comprises both the low project risk (and therefore the low expected return) but also these hedging costs.

Utility-scale plant, USA, (NREL, Dennis Schroeder, NWTC)

CHAPTER 7 - PV in the Power Sector

PV Electricity Production

PV electricity production is easy to measure at a power plant but much more complicated to compile for an entire country. In addition, the comparison between the installed base of PV systems in a country at a precise date and the production of electricity from PV are difficult to compare: A system installed in December will have produced only a small fraction of its regular annual electricity output. For these reasons, the electricity production from PV per country that is showed here is an estimate.

How much electricity can be produced by PV in a defined country?

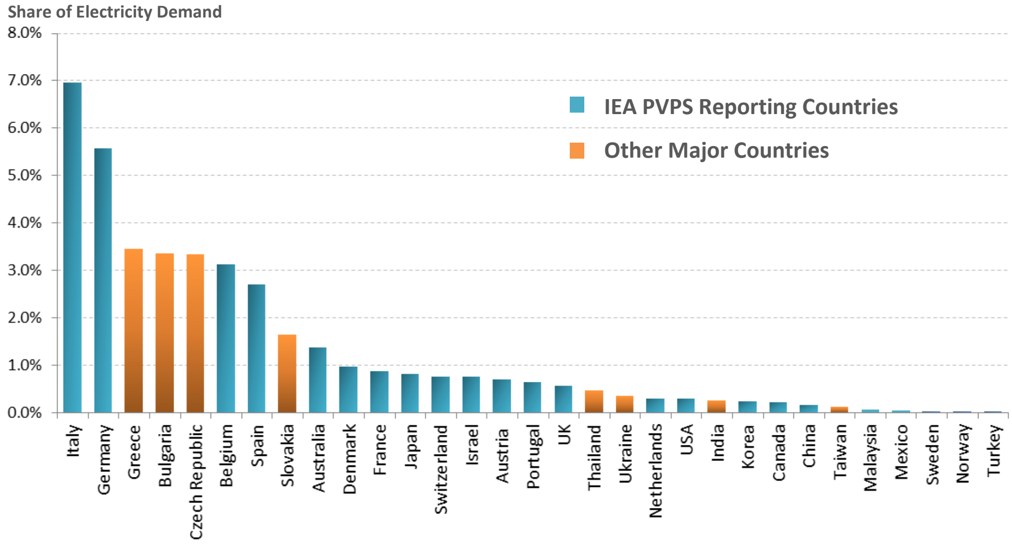
- Estimated PV installed and commissioned capacity at 31-12-2012
- Average theoretical PV production in the capital city of the country (using solar irradiation databases: JRC's PVGIS, SolarGIS, NREL's PVWATT or, when available, country data)
- Electricity demand in the country based on the latest available data.

Figure 21 shows how PV theoretically contributes to the electricity demand in IEA PVPS countries, based on the PV base at end 2012.

Italy remains the number one country with close to 7% of its electricity that will come from PV in 2013. This number can be translated into 14% of the peak electricity demand. In Germany with more than 5,6%, the 32 GW installed in the country produce some days up to 45% of the instantaneous power demand, and around 14% of the electricity during the peak periods.

Three countries outside the IEA PVPS network have the ability to produce more than 3% of their electricity demand: Greece (that will most probably be around 5% based on the 2013 installed capacity), Bulgaria and Czech Republic. Belgium is producing 3% of its electricity thanks to PV and Spain remains below the 3% mark. Slovakia and Australia have reached the 1% mark, while many other countries have lower production numbers.

Figure 21: Theoretical PV Electricity Production Based on Installed Capacity End 2012

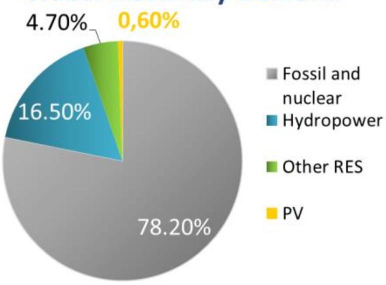


Global PV Electricity Production

With at least 96,5 GW installed all over world, PV could produce on a yearly basis around 115 TWh of electricity. With the world electricity consumption at 19 000 TWh in 2012, this represents 0,6%. Figures 22 and 23 (source: REN21 and IEA PVPS) compare this number to other electricity sources, and especially renewables.

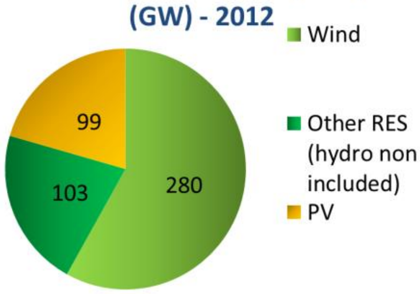
PV represents 20% of the world's installed capacity of renewables, excluding hydropower. In the last twelve years in Europe, PV's installed capacity ranked third with 70 GW installed according to the European Photovoltaic Industry Association, after gas (121 GW) and wind (98 GW), ahead of all other electricity sources, while conventional coal and nuclear were decommissioned. This translated in 2012 into 25% of the European electricity demand being covered by renewables (including hydro), and for the first time ahead of nuclear electricity down at 24%.

Figure 22: Share of PV in the Global Electricity Demand



The trend is not so different outside of Europe: The Republic of Korea for instance installed around 5,1 GW of new power generation capacity in 2012, to be compared with 230 MW of PV. In Australia, 1 482 MW of power generation capacity were installed in 2012, out of which 70% were PV systems. In Japan, where most nuclear plants are still offline, PV represented 35% of all new power generation installations in 2012. In Canada this number reached 10%, while PV develops mainly in one single province.

Figure 23: Share of PV in the Total RES Installed Capacity (GW) - 2012



In 2012, China installed more than 80 GW of new power generation capacities, including 16 GW of wind, 15 GW of hydropower and 3,5 GW of PV. This places the share of renewables in new installations in China just below 50%. The same trend can be seen in the USA, with PV and wind together representing slightly more than 50% of all new power generation capacities.

Table 14: PV Electricity Statistics in IEA PVPS Countries

	Final Electricity Consumption	Habitants	Nominal GDP	Surface	PV installations in 2012	PV installed capacity	PV electricity production	2012 Installations per habitant	Total Capacity per Habitant	Total Capacity per km²	% Demand Electricity
	TWh	Million	Billion USD	km²	MWp	MWp	TWh	W/Hab	W/Hab	kW/km²	%
Australia	229	22	1379	7692024	1038	2415	3,1	48,3	112,3	0,3	1,4
Austria	56	8	418	83871	176	363	0,4	20,9	43,2	4,3	0,7
Belgium	82	11	514	30528	641	2698	2,6	57,8	243,1	88,4	3,1
Canada	505	35	1736	9984670	269	827	1,0	7,7	23,6	0,1	0,2
China	4693	1355	7318	9596961	3500	6800	8,8	2,6	5,0	0,7	0,2
Denmark	32	6	334	43094	315	332	0,3	55,3	58,3	7,7	1,0
France	478	66	2773	640294	1079	4033	4,2	16,3	60,7	6,3	0,9
Germany	607	80	3601	357114	7604	32462	33,8	94,7	404,3	90,9	5,6
Israel	46	8	243	22072	47	237	0,3	5,9	29,6	10,7	0,7
Italy	310	61	2194	301336	3647	16450	21,5	60,2	271,5	54,6	7,0
Japan	860	128	5867	377930	1718	6632	7,0	13,5	52,0	17,5	0,8
Korea	455	50	1116	99828	230	959	1,2	4,6	19,2	9,6	0,3
Malaysia	95	30	288	330803	27	35	0,1	0,9	1,2	0,1	0,1
Mexico	204	117	1153	1964375	15	52	0,1	0,1	0,4	0,0	0,0
Netherlands	112	17	836	37354	195	345	0,3	11,5	20,3	9,2	0,3
Norway	111	5	486	323782	0	10	0,0	0,0	2,0	0,0	0,0
Portugal	51	11	237	92090	66	210	0,3	6,2	19,8	2,3	0,6
Spain	270	46	1477	505992	234	4706	7,3	5,1	101,9	9,3	2,7
Sweden	132	10	540	450295	8	24	0,0	0,9	2,5	0,1	0,0
Switzerland	58	8	659	41277	226	437	0,4	28,3	54,6	10,6	0,8
Turkey	243	76	775	783562	2	9	0,0	0,0	0,1	0,0	0,0
UK	329	64	2445	242900	925	1901	1,8	14,5	29,8	7,8	0,6
USA	3889	320	14990	9371175	3362	7272	10,9	10,5	22,7	0,8	0,3

Notes: Red numbers refer to the lowest rank while green numbers refer to the highest one.

Finally, according to the Renewable Energy Policy Network for the 21st century (REN21), renewable electricity source additions represented 115 GW in 2012, above 50% of all power generation additions. PV, with 29 GW represents then 15% of renewable additions and more than 12% of all new power plants in the world. The slowdown of PV development in Europe, that was visible in 2012 after years of growth and its development in several major countries outside of Europe could lead to an accelerated development of the technology. The need for power generation in China and India, in other Asian countries, in South and Central America, in Africa and the Middle East is consequent enough to let PV grow fast outside its pioneer markets of Europe, US and Japan.

Table 15 : Possible Share of PV Electricity in 2020 and 2035

Today 0.5 %	2020	IEA Current Policies scenario	IEA 450 Scenario	2035	IEA Current Policies scenario	IEA 450 Scenario
30 GW a year	310 GW / 375 TWh	1.3 %	1.4 %	760 GW / 1000 TWh	2.5 %	3.1 %
60 GW a year	520 GW / 620 TWh	2.1 %	2.3 %	1420 GW / 1850 TWh	4.6 %	5.8 %
100 GW a year	800 GW / 960 TWh	3.3 %	3.6 %	2300 GW / 3000 TWh	7.4 %	9.4 %

Long Term Projections for PV

The future penetration of PV will depend on the combination of several factors: The first one is obviously the political support to this set of technologies. Without political support in most developed countries, PV will take more time to reach an acceptable level of competitiveness with conventional electricity sources. However the question of political support is also a question of streamlining permit procedures, adapting grid codes in order to be suitable for small and medium size PV systems and of course, maintaining an adequate level of financial support as long as necessary. Without such support, PV will develop mainly in countries where competitive business cases exists, before coming back or arriving at lower prices in the other countries.

Assuming PV system prices will continue to decrease in the coming years and decades, the medium term competitiveness of the technology at least in some market segments leaves little doubt.

At the current market development speed, around 30 GW a year, PV could represent up to 760 GW of installed capacity in 2035, providing around 1 000 TWh of electricity worldwide, however these 30 GW assume no market growth in the coming years. Without taking a stance on what could be the evolution of the market, the table 15 estimates what the penetration of PV could be with 60 GW (twice the capacity installed in 2012) and 100 GW (slightly more than the triple). Electricity consumption scenarios in 2020 and 2035 have been published in 2012 in the International Energy Agency's World Energy Outlook. The 450 scenario assumes 26 500 TWh of electricity demand in 2020 and 31 750 TWh in 2035 while the "current policies" scenario assumes 29 200 TWh in 2020 and 40 364 TWh in 2035.

In the best case, PV could reach close to 10% of the world electricity demand in 2035 with 100 GW of installations a year, a level that is not that far from the current market reality: the speed at which the PV market grew in the last few years shows that tripling the production is achievable for all actors.

As shown in the table 15, the necessary yearly installations to reach high penetration levels of PV in 2030 and 2050 are not unachievable. Most countries in the world haven't started yet to deploy PV, and this is even truer in the sunniest regions. Achieving a global PV market around 50 or 100 GW could become a reality in the coming years.

Utilities Involvement in PV

In this section, the word "Utilities" will be used to qualify electricity producers and retailers. In some parts of the world, especially in Europe, the management of the electricity network is now separated from the electricity generation and selling business. This section will then focus on the role of electricity producers and retailers in developing the PV market.

In **Europe**, the involvement of utilities in the PV business remains quite heterogeneous, with major differences from one country to another. In Germany, where the penetration of PV provides already more than 5% of the electricity demand, the behavior of utilities can be seen as a mix of an opposition towards PV development and attempts to take part to the development of this new business: Companies such as E.ON have established subsidiaries to target the PV on rooftop customers and some could start their commercial operations already in 2013. In 2012 the **German** utility RWE announced its intention to develop large PV plants and to offer its customers

PV solutions. Other utilities in Germany are moving in a similar direction.

In **France**, EDF, the main utility in the country has set-up a subsidiary that develops utility-scale PV plants in Europe and North America. At the end of 2012, EDF-EN owned some 447 MW of PV systems. In addition, another subsidiary of EDF, EDF-ENR took over the integrated producer of PV modules, Photowatt, present along the whole value chain. The same subsidiary offers PV systems for small rooftop applications (11 600 installations in 2012), commercial, industrial and agricultural applications. Two other major French energy actors are present in the PV sector: GDF Suez, the French gas and engineering company develops utility-scale PV plants while Total, the French oil and gas giant, has acquired SunPower and restructured its industrial activities in the PV sector in 2012.

In **Italy**, the main utility owns a RES-focused subsidiary, ENEL GREEN POWER, that invests and builds utility-scale PV power plants all over the world, including in its home country. At the end of 2012, EGP had 161 MW of PV power plants in operation. In addition, it produces amorphous silicon PV modules through a joint venture with Sharp and STMicroelectronics in Italy.

In several European countries, small local utilities are taking a positive approach towards the development of PV, as in **Sweden** or **Switzerland**. In **Denmark**, EnergiMidt made use of capital incentives for a couple of years for its customers willing to deploy PV.

In **Japan**, utilities made plans to build at least 140 MW of PV systems across the country by 2020 and started to use PV in their own facilities. At the end of 2012, some 65 MW started operations.

In **Canada**, the Calgary Utility developed its Generate Choice Programme where it offers customers a selection of pricing programmes for 1,3 kW systems or more. In Ontario, several utilities are offering solar installations and maintenance programmes for their customers. Roof leasing exists in parallel to the offering of turnkey solutions. Utility involvement offers them a better control on the distribution systems that they operate and the possibility to offer additional services to their customers.

In the **USA**, in addition to similar offerings, some utilities are starting to oppose PV development, and especially the net-metering system. In Arizona and California, the debate will be quite intense in 2013, about the viability of net-metering schemes for PV.

In **Australia**, the fast development of PV has raised concerns about the future business model of utilities. Established generators are losing market share, especially during the daytime peak load period where electricity prices used to be quite high. However, the two largest retailers have stepped into the PV business, capturing significant market share.

In addition to conventional utilities, large PV developers could be seen as the utilities of tomorrow; developing, operating and trading PV electricity on the markets. A simple comparison between the installed capacity of some renewable energy developers and conventional utilities shows how these young companies have succeeded in developing much more plants than older companies.

Inverters at a 555 kW commercial PV plant, Kölliken, Switzerland – Courtesy of EcoenergieA+, Schöftland, Switzerland

Conclusion - Challenges for the Future

At first sight the development of PV in the world stagnated in 2012. However, looking at the details reveals a different picture: The large deployment of PV in Europe in 2011 was mainly driven by the huge installation levels in Italy (9,3 GW) and Germany. The deployment of PV slowed down in 2012 in Europe around 17 GW, to be compared to around 23 GW the year before. In parallel, non-European countries grew fast in 2012, with China, the USA, Japan and Australia ensuring the market development. This trend should be confirmed in 2013, with Europe declining and PV developing in many locations around the world. All continents should see PV development with Chile and South Africa, to mention only these countries, becoming new market spots from 2013 or 2014.

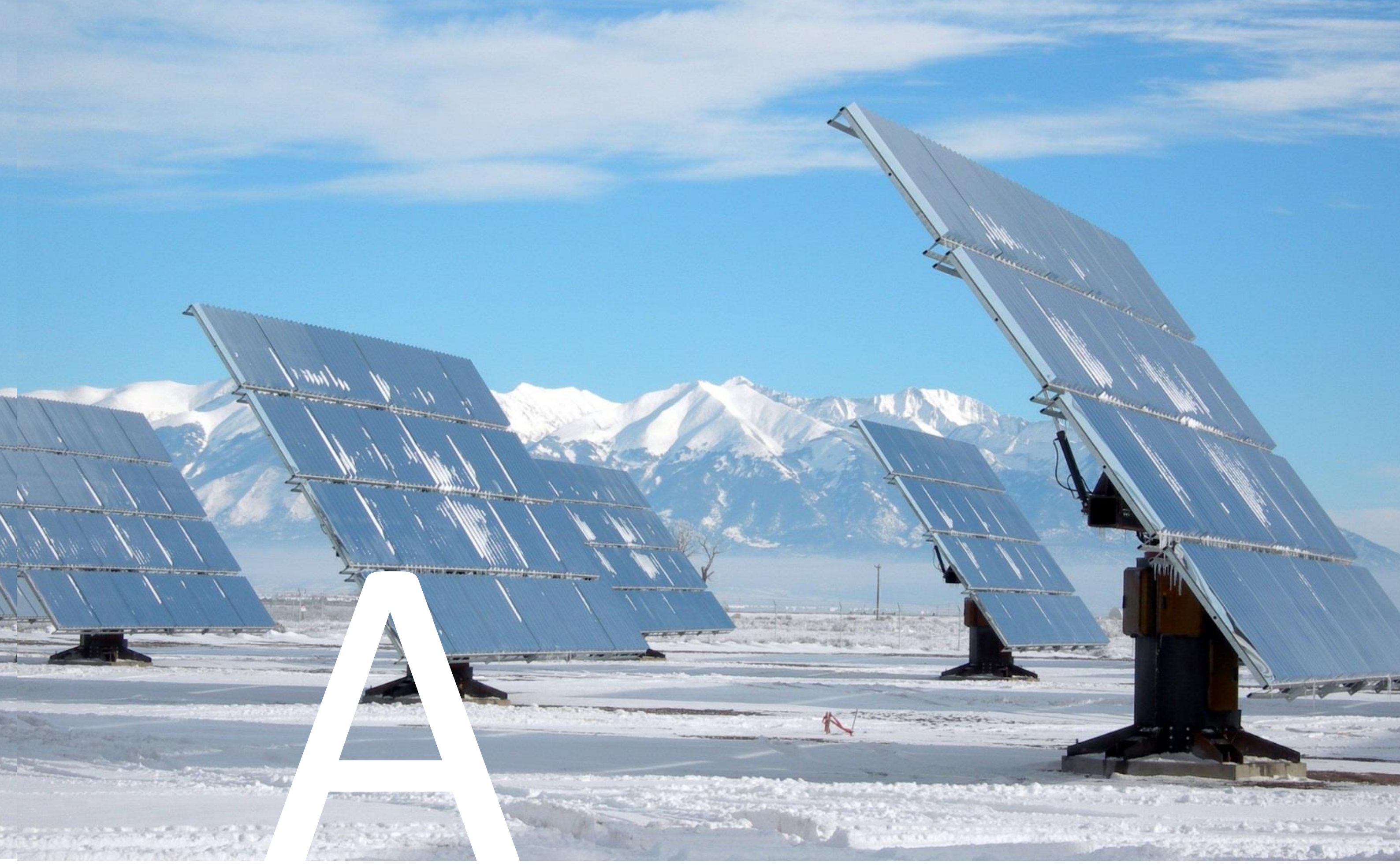
Asia seems to become the new market focal area, with several markets progressing in 2012. Next to China and Japan, Thailand, Korea, Taiwan and of course India are starting or continuing to develop. However, the Americas are following, even if the number of countries were PV is developing was smaller in 2012.

The price decrease that has been experienced in 2011 and 2012 has brought several countries and market segments close to a certain level of competitiveness. This is true in Germany or Italy where the retail price of electricity in several segments of consumers is now higher than the production cost of PV electricity. This is true in several other countries for utility-scale PV or hybrid systems. These declining prices are opening new business models for PV deployment. PV is more and more seen as a way to produce electricity locally rather than buying it from the grid. Self-consumption opens the door for the large deployment of PV on rooftops, and the transformation of the electricity system in a decentralized way. In parallel, large scale PV continued to progress, with plants up to 250 MW. The largest one opened in 2012 in Arizona, USA, with 250 MW and the second one in India with 214 MW. Each year, larger plants are connected to the grid and plans for even bigger plants are disclosed. However, PV is not only on the rise in developed countries and offers adequate products to bring electricity in places where grids are not yet developed. The decline of prices for off-grid systems offers new opportunities to electrify millions of people around the world who never benefited from it before.

The challenges are still numerous before PV can become a major source of electricity in the world: The way how distribution grids could cope with high shares of PV electricity, generation adequacy and balancing challenges in systems with high shares of variable renewables, and the cost of transforming existing grids will be at the cornerstone of PV deployment in the coming years. Moreover, the ability to successfully transform electricity markets to integrate PV electricity in a fair and sustainable way will have to be scrutinized.

Finally, the ability of the PV industry to lower its costs in the coming years and to present innovative products gives little doubt: The price of PV electricity will continue to decline and accordingly, its competitiveness. The quest for PV installation quality will continue and will improve together the PV system reliability and lower the perceived risk of owning and maintaining PV power plants.

The road to PV competitiveness is open but remains complex and linked to political decisions. Nevertheless, the assets of PV are numerous and as seen in this edition of the IEA PVPS Trends report, the appetite for PV electricity grows all over the world. The road will be long before PV will represent a major source of electricity in most countries, but as some European countries showed in the last years, PV has the ability to continue progressing fast.



Alamosa Photovoltaic Plant, Colorado, USA, Suntech modules, built by Sunedison.

Annexes

What is the IEA PVPS?

The International Energy Agency (IEA), founded in 1974, is an autonomous body within the framework of the Organization for Economic Cooperation and Development (OECD). The IEA carries out a comprehensive programme of energy cooperation among its 28 members and with the participation of the European Commission. The IEA Photovoltaic Power Systems Programme (IEA PVPS) is one of the collaborative research and development agreements within the IEA and was established in 1993. The mission of the programme is to "enhance the international collaborative efforts which facilitate the role of photovoltaic solar energy as a cornerstone in the transition to sustainable energy systems."

In order to achieve this, the Programme's participants have undertaken a variety of joint research projects in PV power systems applications. The overall programme is headed by an Executive Committee, comprised of one delegate from each country or organisation member, which designates distinct 'Tasks,' that may be research projects or activity areas. This report has been prepared under Task 1, which facilitates the exchange and dissemination of information arising from the overall IEA PVPS Programme. The participating countries are Australia, Austria, Belgium, Canada, China, Denmark, France, Germany, Israel, Italy, Japan, Korea, Malaysia, Mexico, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States of America. The European Commission, the European Photovoltaic Industry Association, the Solar Electric Power Association, the Solar Energy Industries Association and the Copper Alliance are also members. Thailand is in the process of joining the programme.

PV Market Statistics 1992 to 2012

Table 16: Cumulative Installed PV Power (MW) in IEA PVPS Reporting Countries: Historical Perspective from 1992 to 2012

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Australia	7,3	8,9	10,7	12,7	15,9	18,7	22,5	25,3	29,2	33,6	39,1	45,6	52,3	60,6	70,3	82,5	104,5	187,6	570,9	1376,8	2415,0
Austria	0,0	0,0	0,0	0,0	0,0	0,0	2,9	3,7	4,9	6,5	10,3	16,8	21,1	24,0	25,6	28,7	32,4	52,6	95,5	187,2	362,9
Belgium	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	23,7	107,1	635,7	1054,9	2056,9	2698,4
Canada	1,0	1,2	1,5	1,9	2,6	3,4	4,5	5,8	7,2	8,8	10,0	11,5	13,9	16,8	20,5	25,8	32,7	94,6	281,1	558,3	827,0
China	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	19,0	23,5	42,0	52,1	62,1	69,9	79,9	99,9	139,9	299,9	799,9	3299,9	6799,9
Denmark	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	1,5	1,5	1,6	1,9	2,3	2,7	2,9	3,1	3,3	4,6	7,1	16,7	332,2
France	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	26,0	33,0	43,9	81,5	185,9	377,2	1194,3	2953,4	4032,6
Germany	2,9	4,3	5,7	6,7	10,3	16,5	21,9	30,2	89,4	206,6	323,6	473,0	1139,4	2071,6	2918,4	4195,1	6153,1	9959,0	17372,2	24857,5	32461,6
Israel	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	1,0	1,0	1,3	1,8	3,0	24,5	70,2	189,7	236,7
Italy	8,5	12,1	14,1	15,8	16,0	16,7	17,7	18,5	19,0	20,0	22,0	26,0	30,7	37,5	50,0	120,2	458,3	1181,3	3502,3	12802,9	16450,3
Japan	19,0	24,3	31,2	43,4	59,6	91,3	133,4	208,6	330,2	452,8	636,8	859,6	1132,0	1421,9	1708,5	1918,9	2144,2	2627,2	3618,1	4914,0	6631,7
Korea	0,0	0,0	1,7	1,8	2,1	2,5	3,0	3,6	4,2	4,9	5,4	6,0	8,5	13,5	35,8	81,2	356,8	523,7	650,3	729,2	959,2
Malaysia	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	5,5	7,0	8,8	11,1	12,6	13,5	34,9
Mexico	0,0	0,0	8,8	9,2	10,0	11,0	12,0	12,9	13,9	15,0	16,2	17,1	18,2	18,7	19,7	20,8	21,8	25,0	30,6	37,1	51,8
Netherlands	1,6	1,6	2,0	2,4	3,3	4,0	4,0	9,2	12,6	20,5	26,3	46,0	49,6	51,2	52,7	61,8	65,9	76,8	98,6	150,4	345,4
Norway	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	6,4	6,6	6,9	7,3	7,7	8,0	8,3	8,7	9,1	9,5	10,0
Portugal	0,2	0,2	0,3	0,3	0,4	0,5	0,6	0,9	1,1	1,3	1,7	2,1	2,7	3,0	3,4	17,9	68,0	102,2	130,8	143,6	209,7
Spain	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	11,5	24,1	50,4	154,3	739,2	3635,1	3698,1	4109,7	4471,9	4706,1
Sweden	0,8	1,0	1,3	1,6	1,8	2,0	2,3	2,5	2,7	2,9	3,2	3,4	3,7	4,0	4,3	4,6	4,8	8,8	11,5	15,9	24,3
Switzerland	4,7	5,8	6,7	7,5	8,4	9,7	11,5	13,4	15,3	17,6	19,5	21,0	23,1	27,1	29,7	36,2	47,9	73,6	110,9	211,1	437,0
Turkey	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	8,5
UK	0,0	0,1	0,1	0,2	0,2	0,4	0,5	0,9	1,7	2,5	3,9	5,7	8,0	10,7	14,1	17,9	22,3	25,8	69,6	975,8	1900,8
USA	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	28,0	73,0	131,0	172,0	275,0	427,0	738,0	1172,0	2022,0	3910,0	7272,0
Total	46,0	59,6	84,1	103,5	130,6	176,8	236,8	335,5	551,9	818,0	1196,0	1668,5	2756,5	4096,7	5523,5	8002,6	14342,0	21169,8	35822,2	63881,1	89207,8

Table 17: Annual Installed PV Power (MW) in IEA PVPS Reporting Countries: Historical Perspective from 1993 to 2012

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Australia	1,6	1,8	2,0	3,2	2,8	3,8	2,8	3,9	4,4	5,6	6,5	6,7	8,3	9,7	12,2	22,0	83,1	383,3	805,9	1038,2
Austria	0,0	0,0	0,0	0,0	0,0	2,9	0,7	1,2	1,7	3,8	6,5	4,2	3,0	1,6	3,1	3,7	22,0	42,9	91,7	175,7
Belgium	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	23,7	83,4	528,7	419,2	1001,9	641,5
Canada	0,3	0,3	0,4	0,7	0,8	1,1	1,4	1,3	1,7	1,2	1,8	2,1	2,9	3,7	5,3	6,9	61,9	186,6	277,2	268,7
China	0,0	0,0	0,0	0,0	0,0	0,0	0,0	19,0	4,5	18,5	10,1	10,0	7,8	10,0	20,0	40,0	160,0	500,0	2500,0	3500,0
Denmark	0,0	0,0	0,0	0,0	0,0	0,0	0,0	1,5	0,0	0,1	0,3	0,4	0,4	0,3	0,2	0,2	1,3	2,5	9,6	315,5
France	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	26,0	7,0	10,9	37,6	104,4	191,3	817,1	1759,1	1079,2
Germany	1,4	1,3	1,1	3,6	6,2	5,5	8,3	59,2	117,1	117,0	149,4	666,4	932,2	846,7	1276,8	1958,0	3805,9	7413,3	7485,2	7604,2
Israel	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	1,0	0,2	0,3	0,5	1,2	21,5	45,6	119,6	46,9
Italy	3,6	2,0	1,7	0,2	0,7	1,0	0,8	0,5	1,0	2,0	4,0	4,7	6,8	12,5	70,2	338,1	723,4	2322,0	9304,6	3647,4
Japan	5,3	7,0	12,1	16,3	31,7	42,1	75,2	121,6	122,6	184,0	222,8	272,4	289,9	286,6	210,4	225,3	483,0	991,0	1295,8	1717,7
Korea	0,0	1,7	0,1	0,3	0,4	0,5	0,5	0,5	0,7	0,7	0,6	2,6	5,0	22,3	45,4	275,7	166,8	126,7	78,8	230,0
Malaysia	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	5,5	1,5	1,8	2,3	1,5	0,9	27,4
Mexico	0,0	8,8	0,4	0,8	1,0	1,0	0,9	1,0	1,0	1,2	1,0	1,0	0,5	1,0	1,0	1,0	3,3	5,6	6,5	14,7
Netherlands	0,1	0,3	0,4	0,9	0,8	0,0	5,2	3,4	7,9	5,8	19,7	3,6	1,6	1,5	9,1	4,1	10,9	21,8	51,8	195,0
Norway	0,3	0,3	0,3	0,2	0,3	0,2	0,3	0,3	0,2	0,2	0,2	0,3	0,4	0,4	0,3	0,3	0,4	0,4	0,1	0,1
Portugal	0,0	0,1	0,0	0,1	0,1	0,1	0,3	0,2	0,2	0,4	0,4	0,6	0,3	0,4	14,5	50,1	34,2	28,6	12,8	66,1
Spain	0,0	1,0	0,0	0,0	0,0	0,0	1,0	0,0	2,1	3,2	5,3	12,6	26,3	104,0	584,9	2895,9	63,0	411,6	362,3	234,2
Sweden	0,2	0,3	0,3	0,2	0,3	0,2	0,2	0,2	0,2	0,3	0,3	0,3	0,4	0,6	1,4	1,7	0,9	2,7	4,4	8,4
Switzerland	1,1	0,9	0,8	0,9	1,3	1,8	1,9	1,9	2,3	1,9	1,5	2,1	4,0	2,7	6,5	11,5	25,5	37,1	102,6	226,0
Turkey	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	2,0
UK	0,1	0,0	0,1	0,0	0,2	0,1	0,4	0,8	0,8	1,4	1,8	2,3	2,7	3,4	3,8	4,4	3,5	43,8	906,2	925,0
USA	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	28,0	45,0	58,0	79,0	105,0	160,0	298,0	435,0	890,0	1867,0	3362,0
Total	13,9	25,8	19,7	27,3	46,6	60,3	99,9	216,6	268,4	375,2	477,1	1077,2	1378,5	1429,0	2488,3	6327,6	6827,8	14693,2	28044,0	25325,9

PV Market Statistics for the Year 2012

Table 18: Detail of 2012 Market Statistics

	2012 Installations (MW)					2012 Cumulative Capacity (MW)				
	Grid-connected		Off-grid			Grid-connected		Off-grid		
	Decentralized	Centralized	Domestic	Non-domestic	Total	Decentralized	Centralized	Domestic	Non-domestic	Total
Australia	1008	14	10	6	1038	2276	22	65	53	2415
Austria	175	0	0,2	0	176	358	0	4,7	0	363
Belgium	632	9,7			641	2119	580	0	0	2698
Canada	88	181			269	219	547	23	38	827
China	1460	2000	20	20	3500	2196	4392	102	111	6800
Denmark	315	0	0,2	0,2	315	331	0	0,5	0,7	332
France	756	323	0	0	1079	3032	971	0	0	4033
Germany					7604					32462
Israel	47	0	0,2	0	47	233	0	3,7	0,3	237
Italy	1832	1815	0	1	3647	6040	10399	0	11	16450
Japan	1523	189	3,3	2,8	1718	6264	258	8,8	101	6632
Korea	60	170	0	0	230	207	747	1	5	959
Malaysia	22	5,4	0	0	27	27	0	8	0	35
Mexico					15					52
Netherlands	195	0	0	0	195	340	5	0	0	345
Norway	0	0	0,5	0	0,5	0	0	0	0	10
Portugal					66					210
Spain (*DC numbers*)					234					4706
Sweden	6,9	0,7	0,8	0	8,4	16	1,1	6,5	0,8	24
Switzerland	226	0			226	433	0	4	0	437
Turkey					2					8,5
UK					925					1901
USA	1561	1801			3362					7272
Total IEA PVPS					**25290**					**89227**
8 major non-IEA PVPS markets (source EPIA)					3253					7072
Rest of the world estimates (source EPIA)					755					2983
Total					**29298**					**99282**

Exchange Rates

Currencies are either presented as the current national currency (where it is considered that the reader will receive most benefit from this information) or as euros (EUR) and/or US dollars (USD) (where direct comparisons between countries' information is of interest). Care should be taken when comparing USD figures in this report with those in previous reports because of exchange rate movements. The exchange rates used for the conversions are given at the end of this report.

Table 19 : Average 2012 Currencies Exchange Rates

	Currency and code	Exchange rate (1 USD =)
Australia	AUD	0,97
Canada	CAD	1
China	CNY	6,31
Denmark	DKK	5,79
Israel	NIS	3,85
Japan	JPY	80,5
Korea	KRW	1124
Malaysia	MYR	3,06
Sweden	SEK	6,77
Switzerland	CHF	0,94
United States	USD	1
Austria, Belgium, France, Germany, Italy, The Netherlands, Portugal, Spain	EUR	0,78

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