IEA INTERNATIONAL ENERGY AGENCY

# TRENDS 2015

## IN PHOTOVOLTAIC APPLICATIONS

20TH EDITION 2015

### Survey Report of Selected IEA Countries between 1992 and 2014

PVPS

PHOTOVOLTAIC
POWER SYSTEMS
PROGRAMME

Report IEA-PVPS T1-27:2015

COVER IMAGE
100 kW PV system on top of the Denver Museum of Nature and Science.


## REPORT SCOPE AND OBJECTIVE

Annual surveys of photovoltaic (PV) power applications and markets are carried out in the reporting countries, as part of the IEA PVPS Programme's work.

The Trends reports objective is to present and interpret developments in the PV power systems market and the evolving applications for these products within this market. These trends are analysed in the context of the business, policy and nontechnical environment in the reporting countries.

This report is prepared to assist those who are responsible for developing the strategies of businesses and public authorities, and to support 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. Data accuracy 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 20th international survey. It provides an overview of PV power systems applications, markets and production in the reporting countries and elsewhere at the end of 2014 and analyses trends in the implementation of PV power systems between 1992 and 2014. 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 IEA PVPS 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, the validity of some of these data cannot be assured with the same level of confidence as for IEA PVPS member countries.

## DISCLAIMER

Numbers provided in this report, "Trends 2015 in Photovoltaic Applications", are valid at the time of publication. Please note that all figures have been rounded.

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# FOREWORD

**The IEA PVPS Programme is proud to provide you with its 20th edition of the international survey report on Trends in Photovoltaic (PV) Applications up to 2014.**

Tracking the global progress in PV markets and industry systematically since 1992, the "Trends Report" is one of the flagship publications of the IEA PVPS Programme and an important source of unbiased and objective information. The unique series of "Trends Reports" has covered the transition of PV technology from its early and expensive niche market developments in the 1990s to the recent large-scale global deployment and increased competitiveness. 2014 has confirmed the global markets trends and the consolidated market development observed since 2013. The rise of PV markets in Asia and America has been confirmed. Overall, 34 GW of PV were installed in the IEA PVPS member countries during 2014 (2013: 33 GW), whereas the global PV market is estimated to be at around 40 GW. The global installed total PV capacity is estimated at roughly 177 GW at the end of 2014. PV system prices have seen a slower decline than in the years before or even small increases, confirming that the speed of future cost reduction is likely reduced. On the industry supply side, the "bottom of the valley" appears to be overcome and supply is starting to be renewed and/or increased whereas competition remains high. Policy support continues to be relevant but is quickly moving towards new more market oriented business models. In many regions of the world, PV is becoming one of the least cost options for electricity generation from new renewable energy technologies. All of these developments are accompanied by continuous technology evolution, making PV a growing player in the energy field. With its rising level of penetration in electric grids, PV is more and more affecting electricity systems as a whole and the integration into various technical and economic environments becomes crucial. Quantitatively, the number of countries experiencing PV as an essential part of their electricity supply is increasing, with Italy in the first place with around 8% of annual electricity demand coming from PV, followed by Greece (>7%) and Germany (close to 7%). The number of countries covering more than 1% of their electricity supply from PV has increased to above 20 and 2014 has been the first year, where PV has had a share of more than 1% of the global electricity supply. Altogether, these are encouraging signs of a maturing industry which is however only at the early beginning of its future market relevance. Learn all about the details of this exciting development by reading through our 20th edition of the Trends Report!

**Stefan Nowak**
Chairman
IEA PVPS Programme

2014 HAS CONFIRMED THE GLOBAL MARKETS TRENDS AND THE CONSOLIDATED MARKET DEVELOPMENT OBSERVED SINCE 2013. THE RISE OF PV MARKETS IN ASIA AND AMERICA HAS BEEN CONFIRMED.

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S-5! Solar panel mounting clips. © Dennis Schroeder / NREL

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# PV TECHNOLOGY AND APPLICATIONS

## PV TECHNOLOGY

Photovoltaic (PV) devices convert light directly into electricity and should not be confused with other solar technologies such as concentrated solar power (CSP) or solar thermal for heating and cooling. The key components of a PV power system are various types of photovoltaic cells (often 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 SYSTEMS

**Photovoltaic cells** represent the smallest unit in a photovoltaic power producing device, typically available in 12,5 cm and 15 cm square sizes. In general, cells can be classified as either wafer-based crystalline (single crystal and multicrystalline silicon), compound semiconductor (Thin-film), or organic. Currently, crystalline silicon technologies account for more than 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, have remained popular as they are less expensive to produce but are less efficient, with average conversion efficiency around 14-18%. 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 (CPV) systems with tracking systems or for space applications. Thin-film cells are formed by depositing extremely thin layers of photovoltaic semiconductor materials onto a backing material such as glass, stainless steel or plastic. Thin-film modules have lower conversion efficiencies 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. In recent years, perovskites solar cells have reached efficiencies higher than 20% in labs but have not yet resulted in market products.

**Photovoltaic modules** are typically rated between 50 W and 350 W with specialized products for building integrated PV systems (BIPV) at even larger sizes. Wafer-based crystalline silicon modules have commercial efficiencies between 14 and 21,5%. 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. Their efficiency ranges between 7% (a-Si) and 16,3% (CdTe). CPV modules offer now efficiencies up to 36%.

A **PV System** consists in one or several PV modules, connected to either an electricity network (grid-connected PV) or to a series of loads (off-grid). It comprises various electric devices aiming at adapting the electricity output of the module(s) to the standards of the network or the load: inverters, charge controllers or batteries.

## PV TECHNOLOGY / CONTINUED

A wide range of mounting structures has been developed especially for 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 for ground-mounted systems, 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 99%. Most inverters 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 these 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. They are mainly used for off-grid basic electrification, mainly in developing countries.

Off-grid domestic systems provide electricity to households and villages that are not connected to the utility electricity network (also referred to as 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 up to 5 kW in size.

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 telecommunications, 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 generator 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.

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 distribution 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 residential, commercial or industrial 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 rooftop 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.

Small PV array on the roof of the ESIF. © Dennis Schroeder / NREL

# two

## PV MARKET DEVELOPMENT TRENDS

More than twenty years of PV market development have resulted in the deployment of more than 177 GW of PV systems all over the world. However, the diversity of PV markets calls for an in-depth look at the way PV has been developing in all major markets, in order to better understand the drivers of this growth.

### METHODOLOGY

This report counts all installations, both grid-connected and reported 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 are reporting the power output of the PV inverter (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 when necessary (Spain, Japan and Canada for instance), in order to calculate the most precise installation numbers every year. Global totals should be considered as indications rather than exact statistics.

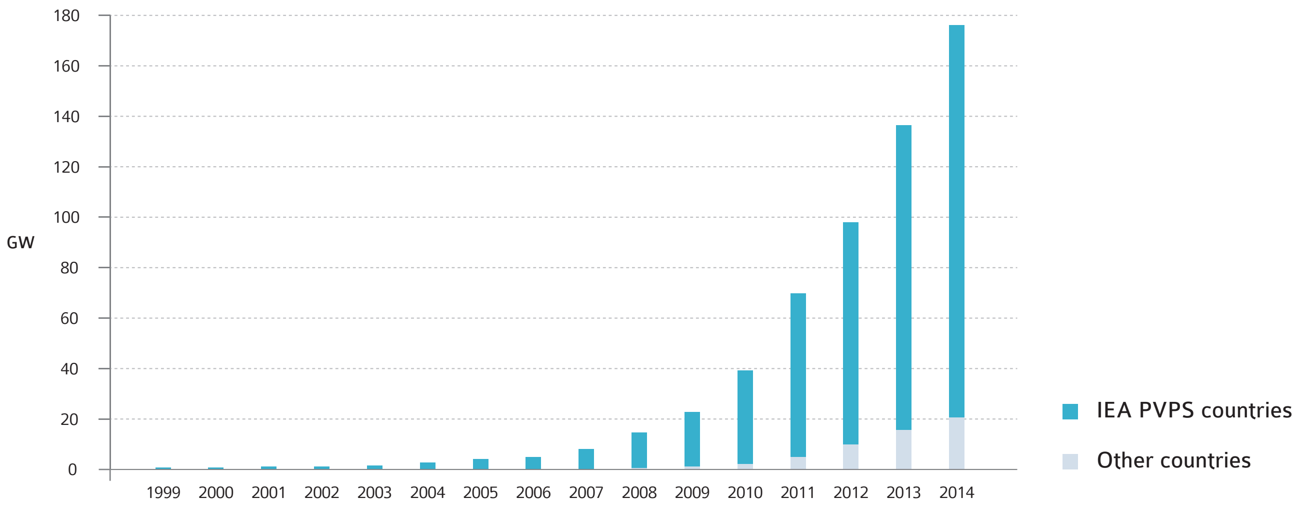
### THE GLOBAL INSTALLED CAPACITY

The IEA PVPS countries represented more than 156 GW of cumulative PV installations altogether, mostly grid-connected, at the end of 2014. The other 38 countries that have been considered and are not part of the IEA PVPS Programme represented 21 additional GW, mostly in Europe: UK with close to 5,3 GW, Greece with 2,6 GW, Czech Republic with 2,1 GW installed, Romania with 1,2 GW and Bulgaria with 1,0 GW and below the GW mark Ukraine and Slovakia. Outside of Europe, the major countries that accounted for the highest cumulative installations in 2014 were India with more than 3 GW, South Africa with 0,9 GW, Taiwan with 0,6 GW and in Chile with 0,4 GW. Numerous countries all over the world have started to develop PV but few have yet reached a significant development level in terms of cumulative installed capacity at the end of 2014 outside the ones mentioned above.

Some sources have recently verified PV shipments in countries outside of the traditional PV markets and concluded that at the end of 2014 an additional 1,6 GW of PV systems have been installed in the last years. (*Latest Developments in Global Installed Photovoltaic Capacity and Identification of Hidden Growth Markets, Werner Ch., Gerlach A., Masson G., Orlandi S., Breyer Ch., 2015*).

Presently it appears that 177 GW represents the minimum installed by end of 2014 with a firm level of certainty.

**FIGURE 1:** EVOLUTION OF PV INSTALLATIONS (GW)



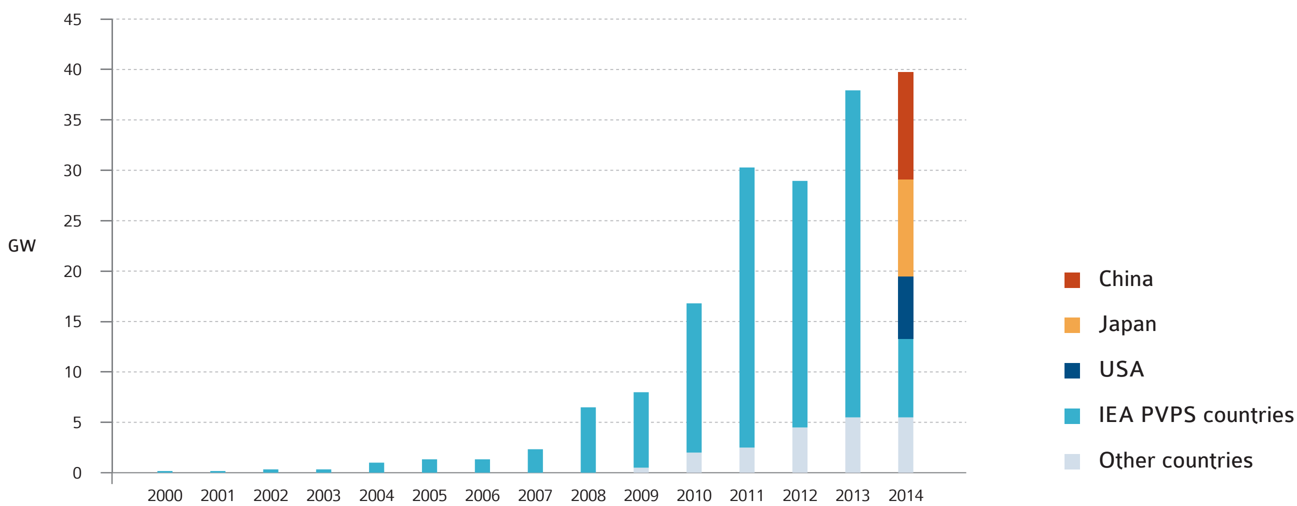

SOURCE IEA PVPS.

## THE MARKET EVOLUTION

The 24 IEA PVPS countries installed at least 34,3 GW of PV in 2014, with a minimum worldwide installed capacity amounting to 39,8 GW. While they are hard to track with a high level of certainty, installations in Non IEA PVPS countries pushed the global annual capacity to around 40 GW in 2014, in the most optimistic case. The remarkable trend of 2014 is the small growth of the global PV market after a year of growth in 2013, and a stagnation in 2012 compared to 2011. Final 2013 market numbers were revised downwards to 38 GW due to a revision of Chinese PV installations. With close to 40 GW, the market grew in 2014 by around 4,6%, again the highest installation ever for PV.

China installed 10,6 GW in 2014, according to the National Energy Administration, a record level slightly lower than the 10,95 GW that placed the country in the first place with regard to all time PV installations in 2013. The initial number of 12,92 GW published last year was revised downwards by the Chinese authorities in 2014. This is perfectly in line with their political will to develop renewable sources and in particular PV in the short to medium term.

**FIGURE 2:** EVOLUTION OF ANNUAL PV INSTALLATIONS (GW)




SOURCE IEA PVPS.

The second place went once again to **Japan**, with 9,7 GW installed in the country in 2014, putting it very close to the Chinese record.

The **USA** installed 6,2 GW of PV systems in 2014, with a growing share of large utility-scale PV compared to rooftop installations.

The **UK** grew significantly in 2014, becoming the first country for PV installations in Europe with 2,4 GW.

**Germany** installed 1,9 GW, after three years at levels of PV installations around 7,5 GW and one year, in 2013 at 3,3 GW. The total installed PV capacity is now more than 38 GW, still the world record in absolute value.

Together, these five countries represent 78% of all installations recorded in 2014 and 72% in terms of installed capacity.

No additional country installed more than 1 GW in 2014. The following five places go to **France** (0,9 GW), **Korea** (0,9 GW), **Australia** (0,9 GW), **South Africa** (0,8 GW) and **India** (0,8 GW). Together these 10 countries cover 90% of the 2014 world market.

**Canada** and **Thailand** installed respectively 633 and 475 MW. **Italy** installed only 424 MW, down from the 9,3 GW in 2011, 3,6 GW in 2012 and 1,7 GW in 2013. They have respectively reached a capacity of 1,9 GW, 1,2 GW and finally 18,6 GW.

Several countries where the PV market used to develop in the last years have performed in various ways: **Belgium** installed only 79 MW and has now reached more than 3 GW. Some countries that grew dramatically over recent years have now stalled or experienced limited additions: **Spain** (22 $MW_{AC}$) now totals 4,8 $GW_{AC}$ of PV systems (respectively DC calculation 22,6 $MW_{DC}$ and 5,4 $GW_{DC}$) followed by **Czech Republic** (2 MW) at 2,1 GW.

In Denmark, the net-metering scheme allowed the PV market to grow quickly but in 2014 the transition to self-consumption pushed the installations down to 42 MW. In the **Netherlands** (400 MW estimated), 2014 saw significant additions while the market stabilized in **Switzerland** (305 MW) and declined in **Austria** (159 MW).

**Malaysia** installed 88 MW for the third year of its Feed-in Tariff (FiT) system. **Taiwan** installed 223 MW in a growing market.

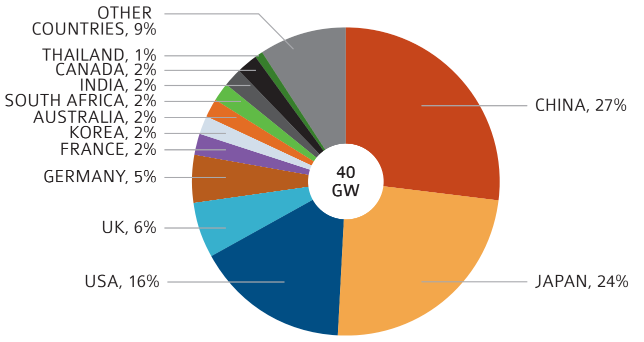
In Latin America, official data for Chile shows the installation of 395 MW, a first step towards PV deployment in the region. Several additional GW of PV plants have been validated in Chile, while projects are popping up in **Brazil** and **Honduras**. The real PV development of grid-connected PV plants has finally started in the region but much more is expected in 2015.

In the Middle East, **Israel** progressed rapidly (200 MW), while the PV installations in **Turkey** have finally started slowly with around 40 MW installed in 2014. Many new projects have been announced, especially in the **UAE** and in **Egypt**.

## A GLOBAL MARKET

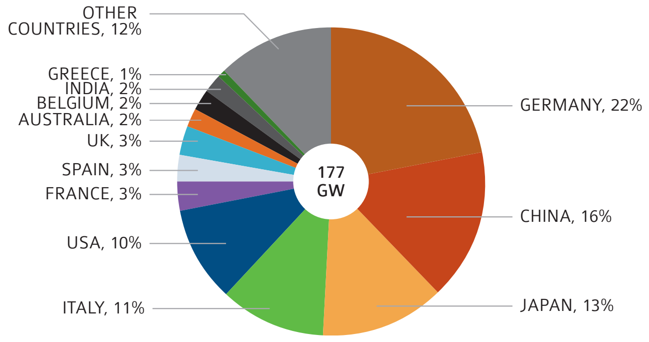
While large markets such as **Germany** or **Italy** have exchanged the first two places from 2010 to 2012, **China**, **Japan** and the **USA** scored the top 3 places in 2013 and 2014. Most top 10 leaders have not changed except Romania which entered the top 10 in 2013 and left in 2014. **France** came back in 2014. The number of small-size countries with impressive and unsustainable market evolutions declined, especially in Europe. In 2014, only major markets reached the top 10, the end of a long term trend seeing small European markets booming during one year before collapsing. 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. **Greece** and **Romania** scored the GW mark in 2013 before collapsing. 2014 started to show a more reasonable market split, with **China**, **Japan** and the **USA** climbing up to the top places, while **India**, the **UK** and **Australia** confirmed their market potential. However, the market level necessary to enter this top 10 that grew quite fast until 2012, declined since then: in 2014 only 779 MW were necessary to reach the top 10, compared to 811 MW in 2013 and 843 MW in 2012. The number of GW markets also declined in 2014 to only five. It can be seen as a fact that the growth of the PV market took place in countries with an already well-established market, while booming markets did not contribute significantly in 2014. The downsizing of several European markets was not compensated by the growth of new markets in Asia or America.

**FIGURE 3:** GLOBAL PV MARKET IN 2014




SOURCE IEA PVPS.

**FIGURE 4:** CUMULATIVE PV CAPACITY END 2014




SOURCE IEA PVPS.

# THE MARKET EVOLUTION / CONTINUED

## PROSUMERS ON THE RISE

The progressive move towards self-consumption schemes has been identified in many countries. While established markets such as Belgium or Denmark are moving away from net-metering on a progressive base (through taxation, for instance), emerging PV markets are expected to set up net-metering schemes. They are easier to set in place and do not require investment in complex market access or regulation for the excess PV electricity. Net-metering has been announced or implemented in Dubai, Lebanon, Chile, Ontario (Canada), some Indian states and more. The trend goes in the direction of self-consuming PV electricity, with adequate regulations offering a value for the excess electricity, either through FiT, net-metering, or net-billing.

## UTILITY-SCALE PROJECTS CONTINUE TO POP UP

The most remarkable trend of 2014 is almost certainly the announcement of utility-scale PV projects in dozens of new countries around the world. Projects are popping up and even if many will not be realized in the end, it is expected that installation numbers will start to be visible in countries where PV development was limited until now. More countries are proposing calls for tenders in order to select the most competitive projects. This trend has continued in 2014 with new countries proposing tenders, including Germany, Dubai, Jordan, Brazil, Honduras and others. Due to the necessity to compete with low wholesale electricity prices, tenders offer an alternative to free installations but constrain the market, while favouring the most competitive solutions (and not always the most innovative).

**TABLE 1:** EVOLUTION OF TOP 10 PV MARKETS

| RANKING | 2012 | 2013 | 2014 |
|---|---|---|---|
| 1 | GERMANY | CHINA | CHINA |
| 2 | ITALY | JAPAN | JAPAN |
| 3 | USA | USA | USA |
| 4 | CHINA | GERMANY | UK |
| 5 | JAPAN | ITALY | GERMANY |
| 6 | FRANCE | UK | FRANCE |
| 7 | AUSTRALIA | ROMANIA | KOREA |
| 8 | INDIA | INDIA | AUSTRALIA |
| 9 | GREECE | GREECE | SOUTH AFRICA |
| 10 | BULGARIA | AUSTRALIA | INDIA |
| MARKET LEVEL TO ACCESS THE TOP 10 | | | |
| | 843 MW | 811 MW | 779 MW |

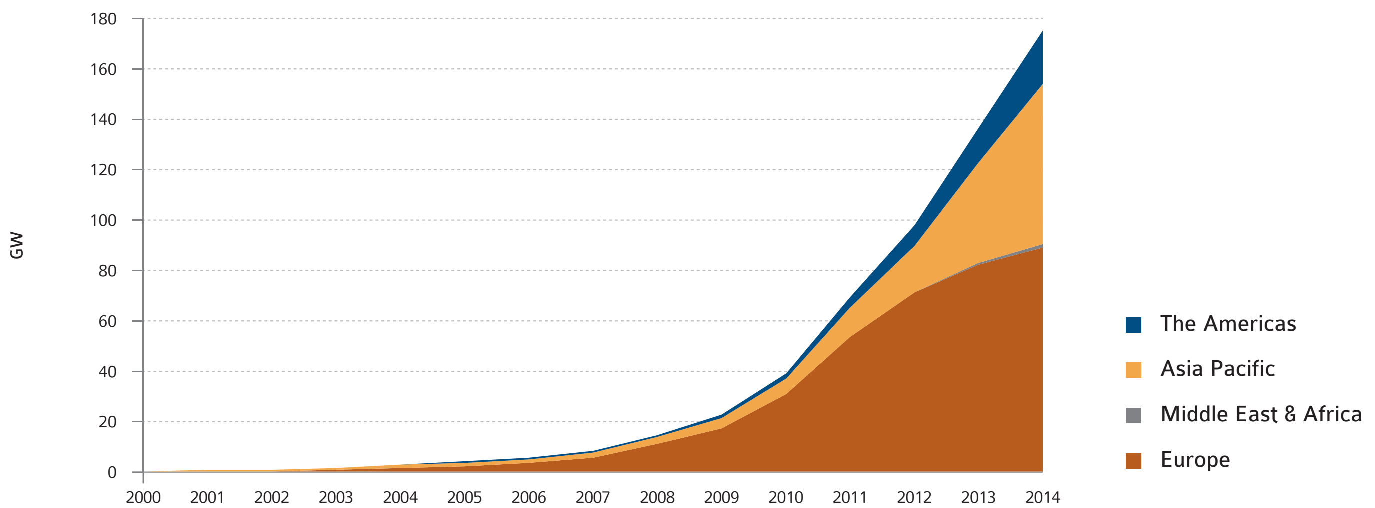
SOURCE IEA PVPS.

## LARGEST ADDITIONS EVER

Italy's record of 9,3 GW yearly installed power has been beaten in 2013 by China with its 10,95 GW; but has not been beaten in 2014 with its 10,6 GW installed. Japan with 9,7 GW in 2014 and 6,9 GW in 2013 represents the 2nd entry in this list for both years. The USA with its 6,2 GW installed in 2014 ranked in 3rd place followed by the UK. Even with 1,9 GW, Germany's installations in 2014 position the country in the top 10; losing one place when compared to 2013. Countries that installed at least 1 GW of PV systems in one year have decreased for the first time in years. Only five countries reached the GW mark in 2014 while several others were just below the mark (France, Korea, Australia, South Africa and India).

As highlighted also in Figure 5, PV capacity additions have moved from Europe to Asia since 2012.

**FIGURE 5:** EVOLUTION OF REGIONAL PV INSTALLATIONS (GW)




SOURCE IEA PVPS.

## 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 6 clearly shows.

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

In Australia, 16 MW of off-grid systems have been installed in 2014. In China, some estimates showed that 40 MW of off-grid applications have been installed in 2014, with an unknown percentage of hybrid systems. It can be considered that most industrial applications and rural electrification systems are most probably hybrid.

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, with 1,1 MW in Sweden.

In Japan, some MW have been installed, bringing the installed capacity above 125 MW, mainly in the non-domestic segment.

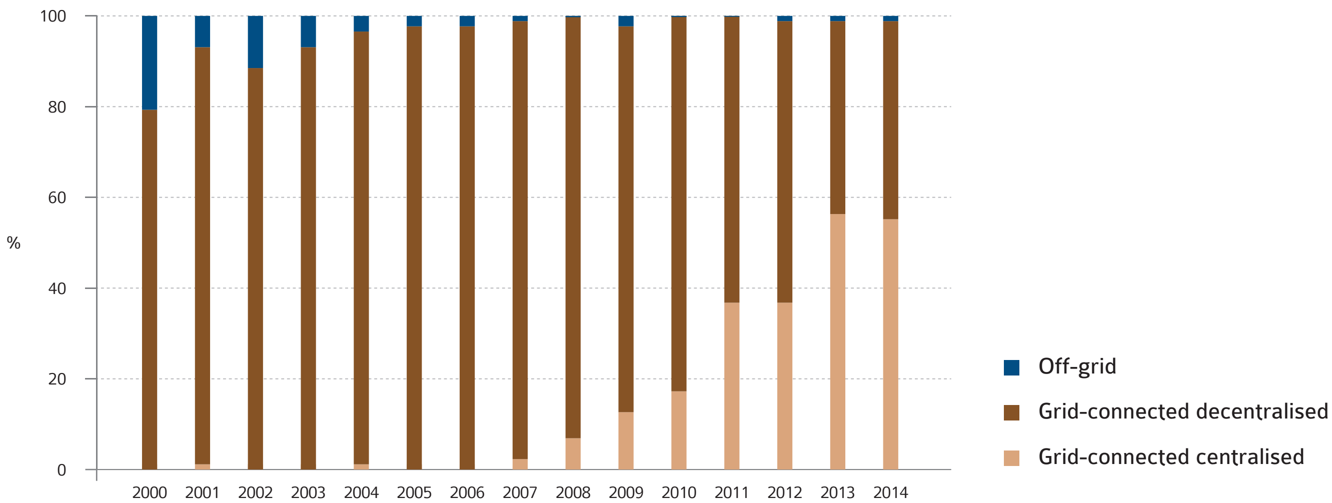
In some countries, off-grid systems with back-up (either diesel generators or chemical batteries) represent an alternative in order to bring the grid into remote areas. This trend is specific to countries that have enough solar resource throughout the year to make a PV system viable. In most developed countries in Europe, Asia or The Americas, this trend remains unseen 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 years. 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 (France) operated more than 150 MW of PV at the end of 2014 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. More than 3 million systems were operational by the end of 2014 with at least 135 MW installed. 6 million PV installations providing basic electricity needs for more than 30 million people are expected by end 2017.

Peru has engaged, as many other countries, in a program of rural electrification with PV.

India has foreseen up to 2 GW of off-grid installations by 2017, including 20 million 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 have not yet been 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 first building complex and costly grids. The challenge of providing electricity for lighting and communication, including access to the Internet, will see the progress of PV as one of the most reliable and promising sources of electricity in developing countries in the coming years.

**FIGURE 6:** SHARE OF GRID-CONNECTED AND OFF-GRID INSTALLATIONS 2000-2014




SOURCE IEA PVPS.

# THE MARKET EVOLUTION / CONTINUED

## ENERGY STORAGE

2014 was a year of significant announcements with regard to electricity storage but in parallel the market is not moving fast. The reason is rather simple: few incentives exist and the number of market where electricity storage could be competitive is reduced. As a matter of fact, only Germany has incentives for battery storage in PV systems and Italy has a tax rebate.

In general, battery storage is seen by some as an opportunity to solve some grid integration issues linked to PV and to increase the self-consumption ratios of PV plants. However, the cost of such a solution prevents them from largely being used for the time being. On large-scale PV plants, batteries can be used to stabilize grid injection and in some cases, to provide ancillary services to the grid.

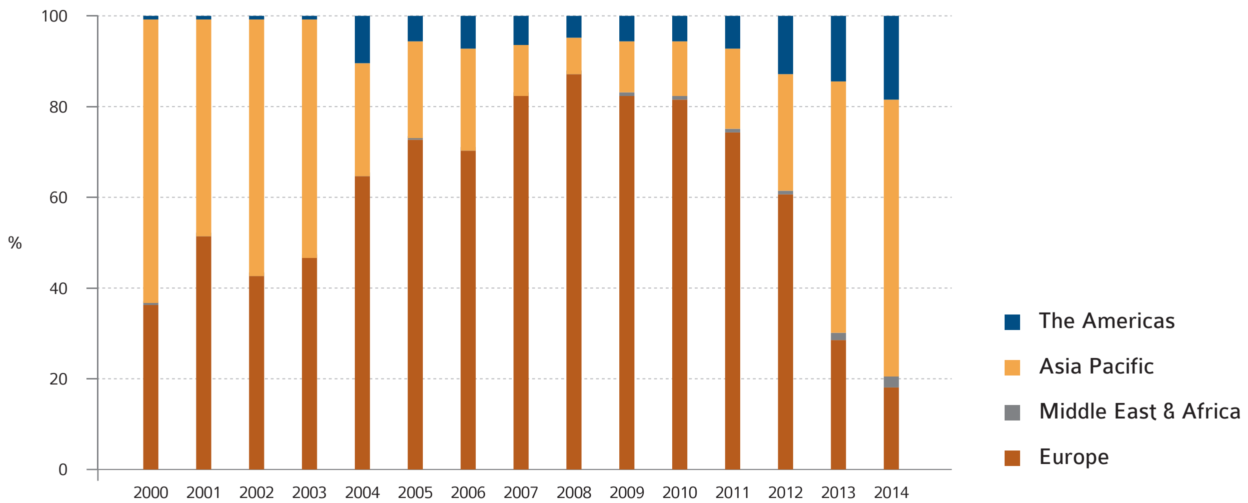
# PV DEVELOPMENT PER REGION AND SEGMENT

The evolution of grid-connected PV towards a balanced segmentation between centralized and decentralized PV has reversed course in 2013 and continued its trend in 2014: centralized PV has evolved faster and most of the major PV developments in emerging PV markets are coming from utility-scale PV. This evolution has different causes. Utility-scale PV requires developers and financers to set up plants in a relatively short time. This option allows the start of using PV electricity in a country faster than what distributed PV requires. Moreover, 2014 saw remarkable progress in terms of PV electricity prices through tenders that are making PV electricity even more attractive in some regions. However, utility-scale has been also criticized when considering environmental concerns about the use of agricultural land, difficulties of reaching competitiveness with wholesale electricity prices in this segment, and grid connection issues, for example. This does not imply the end of development in the utility-scale segment in countries where these issues were met but at least a rebalancing towards self-consumption driven business models. Globally, centralized PV represented more than 50% of the market in 2014, mainly driven by China, the USA, and emerging PV markets.

The same pattern between decentralized and centralized PV is visible in the Asia Pacific region and in the Americas, with a domination of centralized PV installations. This should not 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 large-scale PV installations could also reinforce this evolution and reduce the development of rooftop PV even further.

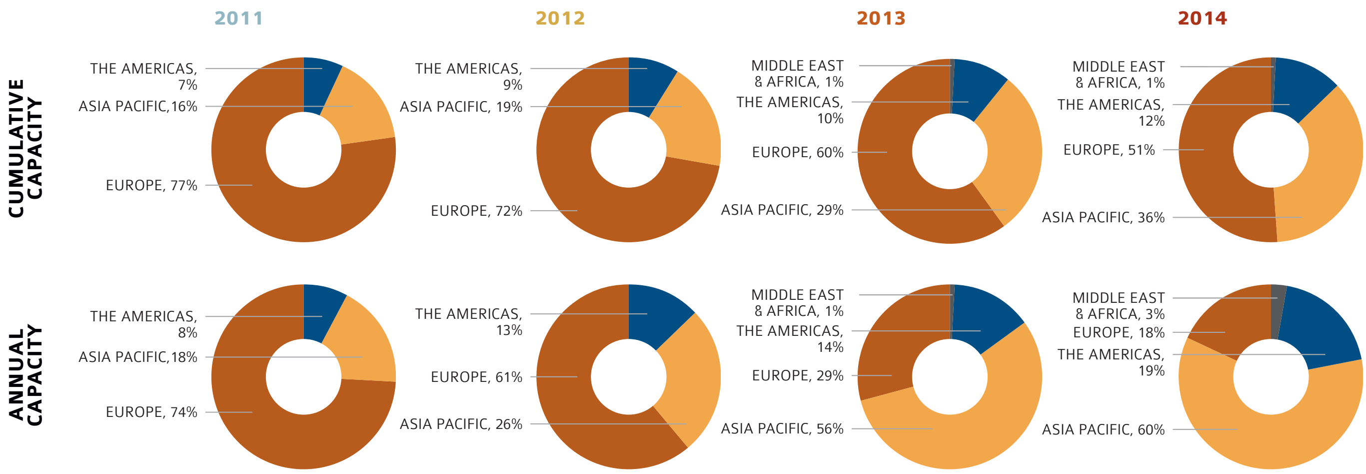
Figure 7 illustrates the evolution of the share of grid-connected PV installations per region from 2000 to 2014. While Asia started to dominate the market in the early 2000s, the start of FiT-based incentives in Europe, and particularly in Germany, caused a major market uptake in Europe. While the market size grew from around 66 MW in 2000 to close to a GW in 2005, the market started to grow 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 fuelled market development while Europe achieved more than 80% of the global market: a performance repeated until 2010.

**FIGURE 7:** SHARE OF GRID-CONNECTED PV MARKET PER REGION 2000-2014




SOURCE IEA PVPS.

**FIGURE 8:** EVOLUTION OF ANNUAL AND CUMULATIVE PV CAPACITY BY REGION 2011-2014




| | CUMULATIVE CAPACITY (MW) | | | | ANNUAL CAPACITY (MW) | | | |
|---|---|---|---|---|---|---|---|---|
| **REGION** | 2011 | 2012 | 2013 | 2014 | 2011 | 2012 | 2013 | 2014 |
| THE AMERICAS | 4 587 | 8 296 | 13 639 | 21 025 | 2 235 | 3 709 | 5 343 | 7 386 |
| ASIA PACIFIC | 11 127 | 18 674 | 39 713 | 63 542 | 5 387 | 7 547 | 21 040 | 23 829 |
| EUROPE | 53 486 | 70 999 | 82 003 | 89 015 | 22 420 | 17 513 | 11 003 | 7 013 |
| MIDDLE EAST & AFRICA | 212 | 277 | 734 | 1 792 | 127 | 65 | 457 | 1 058 |

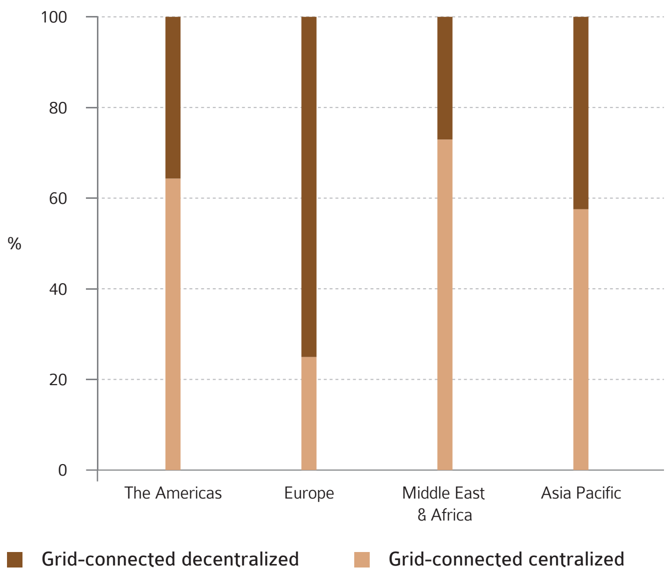
**NOTE** The figure represents only data for tracked countries. Not tracked countries are estimated to represent 1% of the cumulative PV capacity at the end of 2014.

**SOURCE** IEA PVPS.

While Europe still represented a major part of all installations globally in 2014, the share of Asia and The Americas started to grow rapidly from 2012, with Asia taking the lead. This evolution is quite visible from 2011 to 2014, with the share of the Asia Pacific region growing from 18% to 60%, whereas the European share of the PV market went down from 74% to 18% in four years. This trend shows that the development of PV globally is not anymore in the hands of European countries.

Finally, the share of the PV market in the Middle East and in Africa remains relatively small compared to other regions of the world, despite the growth of the South African market and the numerous projects in UAE or Egypt.

**FIGURE 9:** GRID-CONNECTED CENTRALIZED & DECENTRALIZED PV INSTALLATIONS BY REGION IN IEA PVPS COUNTRIES IN 2014




**SOURCE** IEA PVPS.

# THE AMERICAS

The Americas represented 7,4 GW of installations and a total cumulative capacity of 21 GW in 2014. If most of these capacities are located in the USA, and in general in North America, several countries have started to install PV in the centre and south of the continent, and especially in Chile in 2014.

## CANADA

| | | |
|---|---|---|
| FINAL ELECTRICITY CONSUMPTION | 511 | TWh |
| HABITANTS | 36 | MILLION |
| IRRADIATION | 1 150 | kWh/kW |
| 2014 PV ANNUAL INSTALLED CAPACITY | 633 | MW |
| 2014 PV CUMULATIVE INSTALLED CAPACITY | 1 904 | MW |
| PV PENETRATION | 0,4 | % |

At the end of 2014, the installed capacity of PV systems in Canada reached more than 1,9 GW, out of which 633 MW were installed in 2014. Decentralized rooftop applications amounted to 73 MW while large-scale centralized PV systems increased again to 560 MW in 2014 (up from 390 MW in 2013). The market was dominated by grid-connected systems.

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. Installations in Canada are still largely concentrated in the Ontario and driven mostly by the province's FiT.

### Ontario's Feed-in Tariff Programme

While net-metering support schemes for PV have been implemented in most provinces, the development took place mostly in Ontario. This province runs a new FiT system (micro-FiT) for systems below 10 kW with an annual target of 50 MW. The FiT scheme that targets generators above 10 kW and up to 500 kW (the "FiT Programme") was still active in 2014. Eligible PV systems are granted a FiT or microFiT contract for a period of 20 years. In 2014, the FiT levels were reviewed and tariffs were reduced to follow the PV system costs decrease. Above 500 kW, a new system based on a tender (RFQ) has been opened for 140 MW of PV systems under the name of the "Large Renewable Procurement Program". The FiT program is financed by electricity consumers.

Net-metering in Ontario allows PV systems up to 500 kW to self-consume part of their electricity and obtain credits for the excess electricity injected into the grid. However, since the FiT scheme remains more attractive, the net-metering remains marginally used.

PV remained marginal in other provinces in 2014 despite the existence of support schemes in a number of provinces and territories. Only Alberta has more than 1 000 PV systems but with a capacity of 6,4 MW. Net-metering or net-billing schemes are used in these provinces.

## MEXICO

| | | |
|---|---|---|
| FINAL ELECTRICITY CONSUMPTION | 234 | TWh |
| HABITANTS | 124 | MILLION |
| IRRADIATION | 1 780 | kWh/kW |
| 2014 PV ANNUAL INSTALLED CAPACITY | 67 | MW |
| 2014 PV CUMULATIVE INSTALLED CAPACITY | 179 | MW |
| PV PENETRATION | 0,1 | % |

Around 64 MW of PV systems were installed in Mexico in 2014, increasing the total capacity in the country to about 179 MW. Two utility-scale power plants have been developed in 2014, one of 17 MW and another one of 39 MW. At the beginning of 2015, more than 200 projects have been approved with a total capacity of 5 GW. 900 MW were under development at the end of 2014 and are expected to be connected in 2015.

The Mexican government has announced a target of 600 MW of PV systems in 2018 and 6 GW of self-consumption by 2024.

The possibility to achieve accelerated depreciation for PV systems exists at the national level (companies can depreciate 100% of the capital investment during the first year) 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 is already attractive from an economic point of view since they pay more than twice the price of standard consumers. In 2013, the possibility was added for a group of neighbouring consumers (for instance in a condominium) to join together to obtain a permit to produce PV electricity. This net-metering scheme resulted in around 4 100 new systems installed at the end of 2014.

A self-consumption scheme exists for large installations, with the possibility to generate electricity in one point of consumption at several distant sites. In this scheme, the utility charges a fee for the use of its transmission and distribution infrastructure.

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

Rural electrification is supported through the Solar Villages programme.

Large power plants have been announced and could increase the PV market to several hundreds of MW a year.

## USA

| | | |
|---|---|---|
| FINAL ELECTRICITY CONSUMPTION | 3 869 | TWh |
| HABITANTS | 319 | MILLION |
| IRRADIATION | 1 300 | kWh/kW |
| 2014 PV ANNUAL INSTALLED CAPACITY | 6 211 | MW |
| 2014 PV CUMULATIVE INSTALLED CAPACITY | 18 317 | MW |
| PV PENETRATION | 0,6 | % |

Total PV capacity in the USA surpassed 18 GW at the end of 2014 with 6 211 MW added during that year. Once dominated by distributed installations, the USA's market is now lead by large-scale installations, representing 63% of the installed capacity in 2014.

The USA's PV market has been mainly driven by tax credits granted by the federal US government for some years (that will continue at least until end of 2016) with net-metering offered in 44 states as a complementary measure. Meanwhile at least 6 states and 17 utilities are offering power purchase agreements similar to FiTs. 22 states are offering capital subsidies, 29 states have set up an RPS (Renewable Portfolio Standard) system out of which 21 have specific PV requirements. In 2014, some jurisdictions had disputes between utilities and solar advocates that were concluded in favour of net-metering policies. Meanwhile, 6 state public utility commissions and utilities were in the process of developing a Value-of-Solar Tariff (VOST) as an alternative to net-metering at the end of 2014.

In most cases, the financing of these measures is done through indirect public funding and/or absorbed by utilities.

Third party financing developed fast in the USA, with for instance 60% of residential systems installed under the Californian Solar Initiative being financed in such a way. Third parties are also widely used to benefit from tax breaks in the best way. These innovative financing companies cover the high up-front investment through solar leases, for example. Third party financing is led by a limited number of residential third-party development companies, two of them having captured 50% of the market.

With regard to utility-scale PV projects, these are developing under Power Purchase Agreements (PPAs) with utilities.

PACE programmes have been introduced in more than 30 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.

With such a diverse regulatory landscape, and different electricity prices, PV has developed differently across the country.

In December 2012, in an effort to settle claims by US manufacturers that Chinese manufacturers "dumped" product into the US market and received unfair subsidies from the Chinese government, the US Department of Commerce issued orders to begin enforcing duties to be levied on products with Chinese made PV cells. The majority of the tariffs range between 23%-34% of the price of the product. In December 2013, new antidumping and countervailing petitions were filled with the US Department of Commerce (DOC) and the United States International Trade Commission (ITC) against Chinese and Taiwanese manufacturers of PV cells and modules. In Q1 2014, the ITC made a preliminary determination, that "there is a reasonable indication that an industry in the United States is materially injured by reason of imports from China and Taiwan of certain crystalline silicon photovoltaic products."[1] In December of 2014, the DOC issued its new tariffs for Chinese and Taiwanese cells ranging from 11-30% for Taiwanese companies and 75-91% for Chinese companies.

## OTHER COUNTRIES

Several countries in Central and South America have experienced PV market development in 2014. In **Chile**, 395 MW have been installed in 2014 and more are planned for 2015. PV development takes place in a context of high electricity prices and high solar irradiation, the necessary conditions for reaching parity with retail electricity prices. The market is mostly driven by PPAs for utility-scale plants. Brazil, by far the largest country on the continent, has started to include PV in auctions for new power plants and more than 1 048 MW were granted in 2014 with a price around 89 USD/MWh. In addition, **Brazil** has now in place a net-metering systems but with limited results so far. The government has set up a 3,5 GW target for PV in 2023.

In **Argentina**, the Government has set a renewable energy target of 3 GW for 2016. This includes 300 MW for solar PV systems. However, so far the development was quite small, with only a few MW installed in the country.

In **Peru**, 80 MW have been installed in 2012 and 2013. Several programmes related to rural electrification have been started.

The PV market in **Honduras** is expected to boom during 2015 and 2016, as a result of the significant number of systems approved during the 600 MW tender in 2014. However, there is no evidence suggesting that similar measures will be introduced again in the mid-term. As a result, from 2017 onwards, self-consumption PV systems for the residential and commercial sectors are the main segments envisioned to grow.

Several other countries in Central and Latin America have put support schemes in place for PV electricity, such as **Ecuador**.

Other countries, such as **Uruguay**, have launched a call for tender for 200 MW of PV with a PPA in early 2013 at the low 90 USD/MWh rate and projects were approved. The net-metering system launched in 2010 failed to develop the market so far. Several other countries including islands in the Caribbean are moving fast towards PV deployment.

footnote 1 "Certain Crystalline Silicon Photovoltaic Products from China and Taiwan" Investigation Nos. 701-TA-511 8 731-TA-1246-1247 (Preliminary).

# ASIA PACIFIC

The Asia Pacific region installed close to 24 GW in 2014 and more than 63,5 GW are producing PV electricity. This region experienced the fastest market development in 2013 and this continued also in 2014.

## AUSTRALIA

| | | |
|---|---|---|
| FINAL ELECTRICITY CONSUMPTION | 228 | TWh |
| HABITANTS | 24 | MILLION |
| IRRADIATION | 1 400 | kWh/kW |
| 2014 PV ANNUAL INSTALLED CAPACITY | 904 | MW |
| 2014 PV CUMULATIVE INSTALLED CAPACITY | 4 130 | MW |
| PV PENETRATION | 2,5 | % |

After having installed 805 MW in 2011, 1 038 MW in 2012, and 811 MW in 2013, Australia continued in 2014 with 904 MW installed. The country has more than 4,1 GW of PV systems installed and commissioned, mainly in the residential rooftops segment (more than 1,4 million buildings now have a PV system; an average penetration of 15% in the residential sector, with peaks up to 30%), with grid-connected applications. Distributed applications have increased in 2014 with 805 MW and utility-scale is developing with 83 MW installed in 2014. New domestic off-grid applications amounted in 2014 to 12,9 MW in the domestic sector (compared to 9,4 MW in 2013) and 3,2 MW for non-domestic applications. In total Australia counts 148 MW of off-grid systems.

### Market Drivers

Australian Government support programmes impacted significantly on the PV market in recent years. 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 (small-scale PV up to 100 kW, certificates granted for 15 years' worth of production) and LRET by acquiring and surrendering renewable energy certificates created from both large and small-scale renewable energy technologies. Discussions were ongoing in 2014 in order to reduce the RET target.

Large-scale PV benefited from several programs: an auction (ACT programme) was set up in January 2012 for up to 40 MW. The Solar Flagship Programme announced a successful project with 155 MW of large-scale PV planned. In addition, numerous solar cities programmes are offering various incentives that are complementing national programmes.

The market take-off in Australia accelerated with the emergence of FiT programmes in several states to complement the national programmes. In general, incentives for PV, including FiTs, have been removed by State Governments and reduced by the Federal Government.

### Self-Consumption

Self-consumption of electricity is allowed in all jurisdictions in Australia. Currently no additional taxes or grid-support costs must be paid by owners of residential PV systems (apart from costs directly associated with connection and metering of the PV system), although there is significant lobbying from utilities for additional charges to be levied on PV system owners.

There is increasing customer interest in onsite storage. Although not yet cost effective for most customers, a market for storage is already developing.

## CHINA

| | | |
|---|---|---|
| FINAL ELECTRICITY CONSUMPTION | 5 523 | TWh |
| HABITANTS | 1 364 | MILLION |
| IRRADIATION | 1 300 | kWh/kW |
| 2014 PV ANNUAL INSTALLED CAPACITY | 10 640 | MW |
| 2014 PV CUMULATIVE INSTALLED CAPACITY | 28 330 | MW |
| PV PENETRATION | 0,7 | % |

With 10,6 GW installed in 2014, the Chinese PV market has stabilized compared to 2013, achieving the official target of an average of 10 GW of annual installations outlined in the National Action Planning document, issued in 2014. With these installations, the PV capacity rose to close to 28,3 GW, making it the second in the world so far, behind Germany.

Since 2008, utility-scale PV has become the main segment developing in China and this was again the case with 10,2 GW installed in 2013 and 8,55 GW in 2014. More recently rooftop PV has received some interest and starts to develop, in both BAPV (PV on rooftops) and BIPV (PV integrated in the building envelope) segments. In 2013 only 800 MW were installed but it grew significantly in 2014 when more than 2 GW were installed. The growth of centralized PV applications in 2013 and 2014 shows the ability of the FiT regime to develop PV markets rapidly.

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 2014:

- A stable FiT scheme for utility-scale PV and rooftop PV drives the market development. It is entirely financed by a renewable energy surcharge paid by electricity consumers.
- In September 2014, the National Energy Agency (NEA) issued a "Notice on Further Implementation of Policies of Distributed PV Power" that is pushing for PV development on roofs, including PV power applications for large-scale industrial development districts and commercial enterprises with large roofs, high electrical load and high retail electricity prices.
- In October 2014, the NEA and the State Council Leading Group Office of Poverty Alleviation and Development (LGOP) jointly issued a "Work Program on PV Poverty Alleviation Construction Implementation". PV will be used to reduce poverty in 6 pilot provinces "PV poverty alleviation pilot provinces" including Hebei, Shanxi, Anhui, Gansu, Qinghai and Ningxia. The implementation plan of 2015 targets 1,5 GW of installations.
- In November 2014, the USA and China issued a Joint Announcement on Climate Change which mentioned that non-

fossil energy will reach 20% of the primary energy consumption by 2030. Solar power (including PV and solar thermal) should reach at least 400 GW in 2030. This translated into about 20-25 GW of new installations from 2016 onwards.

Since December 2012, 3 FiT levels have been adjusted according to the solar resources and a self-consumption subsidy has been introduced. In September 2014, the feed in tariff policy was adjusted to provide the choice between self-consumption with surplus injection into the grid and full injection into the grid. These options replace the only choice existing before with self-consumption and injection of the surplus into the grid. This intends to make distributed PV revenues more predictable.

While the market is mostly concentrated in the traditional grid connected systems, other types of distributed PV have been developed such as hydro-PV hybrid plants, PV for agricultural greenhouses and ad-hoc PV installations for fisheries.

### Comments

By the end of 2014, the proportion of China's non-fossil energy in primary energy consumption increased from 7,4% in 2005 to 11,2%. Carbon dioxide emissions per unit of GDP dropped 33,8% compared to the 2005 level.

China is the first PV market in the world for the second year in a row. Adequate policies are being put in place progressively and will allow the market to continue at a high level, driven by the climate change mitigation targets that would require to install every year around 25 GW of PV systems. In fact, the market growth started already in the first six month of 2015. 7,73 GW of PV capacity has been installed of which 6,6 GW were utility-scale plants while 1,04 GW were distributed installations.

## JAPAN

| | | |
|---|---|---|
| FINAL ELECTRICITY CONSUMPTION | 965 | TWh |
| HABITANTS | 127 | MILLION |
| IRRADIATION | 1 050 | kWh/kW |
| 2014 PV ANNUAL INSTALLED CAPACITY | 9 740 | MW |
| 2014 PV CUMULATIVE INSTALLED CAPACITY | 23 409 | MW |
| PV PENETRATION | 2,5 | % |

Total annual installed capacity of PV systems reached 9,7 GW (DC) in 2014 in Japan, a 40% increase compared to 2013. The total cumulative installed capacity of PV systems in Japan reached 23,4 GW in 2014.

With the start of the FiT programme in July 2012, the market for public, industrial application and utility-scale PV systems grew fast. Most installations took place after the implementation of the FiT program. The breakdown of PV systems installed in 2014 is 1,4 MW for off-grid domestic application, 9,7 GW for grid-connected distributed application.

While the PV market in Japan developed in the traditional rooftop market which at the end of 2014 represented almost 5 GW of the cumulative capacity, 2013 and 2014 have seen the development of large-scale centralized PV systems, especially in 2014 with 3 GW up from 1,7 GW of centralized plants installed in 2013.

### Investment Subsidy

The subsidy programme, restarted in 2009, aims to promote the dissemination of high-efficiency (depending on the technology, efficiency must be in between 8,5% and 16%) and low-price PV systems below 10 kW. A specific certification scheme has to be met. This instrument terminated at the end of the fiscal year 2013 (April 2014).

### Feed-in Tariff

On 1st July 2012, the existing scheme that allowed purchasing excess PV production was replaced by a new FiT scheme. Its cost is shared among electricity consumers with some exceptions from electricity-intensive industries. This scheme has led to the fast market development seen in Japan in 2013, and more is expected in 2014.

The market was balanced between residential below 10 kW, commercial, industrial and large-scale centralized plants in 2014.

### Self-Consumption

The FiT programme is used to remunerate excess PV electricity not self-consumed for systems below 10 kW. However with tariffs above the retail electricity prices, self-consumption is not incentivized.

### Other Support Schemes

Other schemes exist in Japan, with various aims. A project supporting acceleration for introduction of renewable energy from the METI, was 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 favour 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.

## KOREA

| | | |
|---|---|---|
| FINAL ELECTRICITY CONSUMPTION | 478 | TWh |
| HABITANTS | 50 | MILLION |
| IRRADIATION | 1 258 | kWh/kW |
| 2014 PV ANNUAL INSTALLED CAPACITY | 909 | MW |
| 2014 PV CUMULATIVE INSTALLED CAPACITY | 2 398 | MW |
| PV PENETRATION | 0,6 | % |

Since the record-breaking year of 2008, that saw 276 MW of PV installations, the PV market remained stagnant in Korea during the next three years. This was mainly due to the limited FiT scheme which played initially an important role in the PV market expansion. However, 230 MW in 2012, 530 MW in 2013 and finally 909 MW in 2014, respectively, were installed, reaching the highest level of installations so far. Thanks mainly to the newly introduced RPS scheme (with PV set-aside requirement), the market started to react in 2013 and continued its development in 2014.

## ASIA PACIFIC / CONTINUED

At the end of 2014, the total installed capacity was about 2,4 GW, among those the grid-connected centralized system accounted for around 87% of the total cumulative installed power. The grid-connected distributed system amounted to around 13% of the total cumulative installed PV power. The share of off-grid non-domestic and domestic systems has continued to decrease and represents less than 1% of the total cumulative installed PV power.

Various incentives have been used to support PV development. In 2014, the "Fourth Basic Plan for the Promotion of Technological Development, Use, and Diffusion of New and Renewable Energy" based on the "Second National Energy Basic Plan" was issued. This plan includes many new subsidy measures including the development of "Eco-friendly Energy Towns," "Energy-independent Islands," and "PV Rental Programs." The RPS scheme launched in 2012 will be active until 2024 and is expected to be the major driving force for PV installations in Korea with improved details such as boosting the small scale installations (less than 100 kW size) by adjusting the REC and multipliers, and unifying the PV and non-PV markets.

### RPS Programme

The RPS is a mandated requirement that the electricity utility business sources a portion of their electricity supplies from renewable energy. In Korea, electricity utility business companies (total 17 power producing companies) exceeding 500 MW are required to supply a total of 10% of their electricity from NRE (New and Renewable Energy) sources by 2024, starting from 2% in 2012. The PV set-aside requirement is set to be 1,5 GW by 2015. The PV set-aside requirement plan was shortened by one year in order to support the local PV industry. In 2014 alone, about 865 MW (cumulative 1 437 MW) were installed under this programme. In a cumulative amount, about 58% of the total PV installations in Korea was made under RPS scheme, while total 500 MW (about 20%) was installed under FiT programme which ended in 2011.

### Home Subsidy Programme

This programme was launched in 2004, and merged with the existing 100 000 rooftop PV system installation programme. It aims at the construction of one million green homes utilizing PV as well as solar thermal, geothermal small-size wind, fuel cells and bio-energy until 2020. In general, single-family houses and multi-family houses including apartments can benefit from this programme. The Government provides 60% of the initial PV system cost for single-family and private multi-family houses, and 100% for public multi-family rental houses. The maximum PV capacity allowed for a household is 3 kW. In 2014, the budget allocated for PV in this program was 21 420 MKRW (total budget: 54 920 MKRW).

### Building Subsidy Programme

The Government supports up to 50% of installation cost for PV systems (below 50 kW) in buildings excluding homes. 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. In 2014, the budget allocated for PV in this program was 4 500 MKRW (total budget: 18 000 MKRW). 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 NRE (including PV) systems owned or operated by local authorities. In 2014, the budget allocated for PV in this program was 17 512 MKRW (total budget: 21 000 MKRW).

### 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 12% (in 2014) of their total expected energy from 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 30% by 2020.

### PV Rental Programme

Household owners who are using more than 350 kWh electricity can apply for this program. Owners pay PV system rental fee (maximum monthly 70 000 KRW which is on the average less than 80% of the electricity bill) for a minimum of 7 years and can use the PV system with no initial investment and no maintenance cost for the rental period. PV rental companies recover the investment by earning PV rental fee and selling the REP (Renewable Energy Point) having no multiplier. In 2014, 6 MW (2006 households) were installed under this programme.

### Capital Subsidy (NRE Loan) Programme

This program aims at tackling the up-front cost barrier, either for specific equipment for NRE use or facilities for NRE products. KEA (Korea Energy Agency, formerly KEMCO), through KNREC (Korea New & Renewable Energy Center), evaluates the proposal from the companies and provides the financing fund to participating financial institutions such as banks. The participating banks lend money to the companies with low interest rate (typically 1,75% variable), grace period option (1 to 5 years) and amortization option. This subsidy loan can be used for financing facilities (installation, renovation, etc.), production funds as well as working capital. In 2014, a total budget of 103 400 MKRW was allocated for NRE, and about 20 000 MKRW loan was provided for PV.

## MALAYSIA

| | | |
|---|---|---|
| FINAL ELECTRICITY CONSUMPTION | 119 | TWh |
| HABITANTS | 30 | MILLION |
| IRRADIATION | 1 200 | kWh/kW |
| 2014 PV ANNUAL INSTALLED CAPACITY | 88 | MW |
| 2014 PV CUMULATIVE INSTALLED CAPACITY | 168 | MW |
| PV PENETRATION | 0,2 | % |

The PV market grew significantly in 2014 at 89 MW, up from 52 MW in 2013. The total installed capacity in Malaysia now tops 168 MW. The 2014 grid-connected distributed installations represented 86,7 MW compared to 48,2 MW in 2013.

The residential segment remained stable in 2014 while the commercial segment doubled compared to 2013. The cumulative average size of systems in the commercial and industrial segment is rather high, around 670 kW while it is close to 10,5 kW in the residential segment; a rather high level as well.

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 FiT mechanism.

The FiT Programme is financed by a Renewable Energy Fund (RE Fund) funded by electricity consumers via a 1,6% collection from the consumers' monthly electricity bills. Domestic consumers with a consumption no more than 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.

There was no self-consumption mechanism at the end of 2014. However discussions were ongoing for a possible introduction in 2016.

BIPV installations are incentivized with an additional premium on top of the FiT.

## THAILAND

| | | |
|---|---|---|
| FINAL ELECTRICITY CONSUMPTION | 169 | TWh |
| HABITANTS | 67 | MILLION |
| IRRADIATION | 1 372 | kWh/kW |
| 2014 PV ANNUAL INSTALLED CAPACITY | 475 | MW |
| 2014 PV CUMULATIVE INSTALLED CAPACITY | 1 299 | MW |
| PV PENETRATION | 1,1 | % |

In Thailand, at the end of 2014, the cumulative grid-connected PV power reached 1,3 GW, with around 30 MW of off-grid applications. 475 MW have been installed in 2014, slightly more than in 2013 (436 MW).

The introduction of a feed-in premium or "adder" in Thailand in 2007 aimed at promoting the development of grid-connected solar energy. This "adder" came in addition to the regular tariff of electricity, around 3 THB/kWh. It was phased out at the end of 2013. It has been replaced by a 25-years FiT scheme.

In 2013, the solar power generation target has been increased to 3 GW (and will be increased to 3,8 GW in 2015) together with the reopening of the solar PV rooftop Very Small Power Producer (VSPP) scheme with a new FiT (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). 1 GW has been granted for utility-scale ground-mounted PV systems. The FiT will be paid during 25 years.

In addition, the Thai Government also approved a generation scheme of 800 MW for agricultural cooperatives.

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.

## OTHER COUNTRIES

2014 has seen PV developing in more Asian countries in such a way that Asia is now the very first region in terms of new PV installations. Several countries present interesting features that are described below.

India, with more than 1 billion inhabitants has been experiencing severe electricity shortages for years. The Indian market amounted to around 1 GW in 2012 and 1,1 GW in 2013 before going down to 779 MW in 2014, powered by various incentives in different states. 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 additional 2 GW of off-grid systems, including 20 million solar lights. Some states have announced policies targeting large shares of solar photovoltaic installations over the coming years. Finally, 2 GW of off-grid PV systems should be installed by 2017. However, in 2014 a brand new target of 100 GW was unveiled: 60 GW of centralized PV and 40 GW of rooftop PV. This impressive target will have to be followed by a real market development that should start to be visible in 2015.

In 2014 Taiwan installed about 223 MW mostly as grid-connected roof top installations. The total installed capacity at end of 2014 is estimated around 615 MW. The market is supported by a FiT scheme guaranteed for 20 years and managed 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 initial generous FiT 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. Property owners can receive an additional capital subsidy. It is intended to favour small scale rooftops 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 842 MW of PV installations in 2015, 2,1 GW in 2020 and 6,2 GW in 2030 (3 GW on rooftops, 3,2 GW for utility-scale PV). 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 as the progress of the market shows for 2014.

The Government of Bangladesh has been emphasizing developing solar home systems (SHS) as about half of the population has no access to 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

## ASIA PACIFIC / CONTINUED

from a range of other donors, the government is promoting incentive schemes to encourage entrepreneurs who wish to start PV actions, at present led by the Infrastructure Development Company Ltd. (IDCOL) working with about 40 NGOs. Thanks to the decrease 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 above 3 MSHS (and 135 MW at the end of 2014). More are expected after some financing from the World Bank. The 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). The government started to introduce more PV power by setting a Solar Energy Program and is planning to introduce 500 MW of solar energy by 2017 (340 MW for commercial and 160 MW for grid connection). Bangladesh Power Development Board (BPDB) under the Ministry of Power, Energy and Mineral Resources (MPEMR) signed a PPA for a 60 MW PV power plant in July 2014.

Other Asian countries are seeing some progress in the development of PV. Pakistan has approved 793 MW of solar plants to be commissioned in 2015. A FiT has been introduced for utility-scale PV in 2014. Brunei has announced that a FiT policy should be put in place over the next 18-24 months. The Philippines have installed 30 MW in 2014. The government approved 1,2 GW of utility-scale PV projects in 2014. As it happened in many countries, the tender was oversubscribed. In 2014, Indonesia put in place a solar policy which started already in 2013: Under this regulation, solar photovoltaic power is bought based on the capacity quota offered through online public auction by the Directorate General of New Renewable Energy and Energy Conservation. The plant that wins the auction will sign a power purchase agreement with the National Electric Company at the price determined by the regulation. The maximum purchase price is 0,25 USD/kWh increased to 0,30 USD/kWh in case of a local content requirement of 40%. However, so far only 20 MW were installed in 2014. Myanmar has signed a memorandum for building several large-scale plants. In Singapore, the total PV installed capacity was 30 MW at the end of 2014. 15 MW of PV on rooftops have been installed in 2014, mostly in the commercial and industrial segments. 350 MW are targeted by the government on public buildings. Uzbekistan has the intention to install 2 GW of PV plants and two utility-scale plants are being developed (100 MW and 130 MW). In Kazakstan, the government aims at installing 700 MW and has established a FiT program in 2014. In Nepal, the Electricity Agency planned to develop PV power plants totalling 325 MW by 2017.

## EUROPE

Europe has led PV development for almost a decade now and represented more than 70% of the global cumulative PV market until 2012. Since 2013, European PV installations went down while the rest of the world has been growing rapidly. Europe accounted for 18% of the global PV market with 7,0 GW in 2014. European countries installed 89 GW of cumulative PV capacity by the end of 2014.

### AUSTRIA

| | | |
|---|---|---|
| FINAL ELECTRICITY CONSUMPTION | 57 | TWh |
| HABITANTS | 8,6 | MILLION |
| IRRADIATION | 1 027 | kWh/kW |
| 2014 PV ANNUAL INSTALLED CAPACITY | 159 | MW |
| 2014 PV CUMULATIVE INSTALLED CAPACITY | 787 | MW |
| PV PENETRATION | 1,4 | % |

Austria's support for PV relies on a mix of capped FiT and investment grants. Due to a cap on the tariffs, the development of PV in Austria remained constrained at a relatively low level with a market below 100 MW until 2011. With 175 MW in 2012, 263 MW in 2013 and 159 MW in 2014, the market grew and declined. Off-grid development amounted to 0,3 MW installed in 2014.

Systems below 5 kWp are incentivized through a financial incentive that can be increased for BIPV installations. Above 5 kWp, the Green Electricity Act provides a FiT that was reduced in 2014. The FiT is guaranteed during 13 years and financed by a contribution of electricity consumers. Some financial grants can be added for specific buildings. In addition to federal incentives, most provinces are providing additional incentives through investment subsidies.

Self-consumption is allowed for all systems. Self-consumption fees have to be paid if the self-consumption is higher than 25 000 kWh/y.

Since January 2014, decentralized electricity storage systems in combination with PV systems are supported in the three provinces with an investment grant. Rural electrification in remote areas not connected to the grid is incentivized through an investment subsidy up to 35% of the cost.

In general, the country's support for PV has been characterized by a series of changes that have influenced the market evolution in the last years.

### BELGIUM

| | | |
|---|---|---|
| FINAL ELECTRICITY CONSUMPTION | 79 | TWh |
| HABITANTS | 11 | MILLION |
| IRRADIATION | 990 | kWh/kW |
| 2014 PV ANNUAL INSTALLED CAPACITY | 79 | MW |
| 2014 PV CUMULATIVE INSTALLED CAPACITY | 3 156 | MW |
| PV PENETRATION | 3,6 | % |

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 in 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 kW or 10 kW, a net-metering system exists across the country. Until 2010, further grants were paid in addition to other support schemes while the tax rebates have been cancelled in November 2011.

Flanders started to develop first and installed more than 2,2 GW of PV systems in a few years. In Wallonia, the market started with a two year delay and remains largely concentrated in the residential and small commercial segments with around 800 MW at the end of 2014. In Flanders, large rooftops and commercial applications have developed from 2009. In Wallonia, conditions of self-consumption and energy efficiency considerably limit development of the commercial and industrial segments. 79 MW were installed in the country in 2014, a significant decrease. Belgium runs now 3,16 GW of PV systems.

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 272 $MW_{AC}$ installed solely in the residential segment of the 3 million inhabitants of the region. In 2014, the market went down following the decrease of the number of green certificates allowed and changing policies about grid costs compensation.

At the end of 2013, a grid injection fee (to be paid annually and power-based) that was introduced in Flanders for systems benefiting from the net-metering scheme, was cancelled and then reintroduced in July 2015. The same debate popped up in Wallonia fuelled by the fear of grid operators to see their financing reduced.

In general, the Belgian market is transitioning from an incentive-driven market to a self-consumption-driven market. This transition will imply a revision of net-metering policies and possibly new forms of incentives in the coming years.

## DENMARK

| | | |
|---|---|---|
| FINAL ELECTRICITY CONSUMPTION | 34 | TWh |
| HABITANTS | 6 | MILLION |
| IRRADIATION | 925 | kWh/kW |
| 2014 PV ANNUAL INSTALLED CAPACITY | 42 | MW |
| 2014 PV CUMULATIVE INSTALLED CAPACITY | 606 | MW |
| PV PENETRATION | 1,7 | % |

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 that continued partially in 2013 before the market collapsed in 2014. 42 MW were installed in 2014 and a total of 606 MW were connected to the grid by the end of 2014. The high electricity prices combined together with decreasing system costs for PV systems made this fast development possible.

In November 2012, the government reacted to the 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 reduced the number of installations in 2013 and even more in 2014. 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. In 2014, this transitory net-metering scheme was suspended. PV in 2014 was then incentivized by self-consumption and the FiT for the excess electricity guaranteed during 20 years, with a decreasing value after 10 years. The net-metering system has now a cap of 800 MW (+20 MW for municipal buildings) until 2020.

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 of 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 impacts 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 at EU and national level 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 given share of renewable energy in their mixes so as to reach an overall 20% share of renewable energy in the energy mix at European level. Since the directive from 2009 let all Member States decide about the way to achieve their binding 2020 targets, PV targets were set up in various ways. In October 2014, the EU decided to define targets until 2030 for renewable energy development in the framework of its climate change policies. It sets a new target of at least 27% of renewable energy sources in the energy mix, together with energy savings targets and GHG emissions.

# EUROPE / CONTINUED

Besides the Renewable Energy Directive, the so-called Energy Performance of Building Directive defines a regulatory framework for energy performance in buildings and paves the way for near-zero and positive energy buildings.

The grid development is not forgotten. Dedicated funding schemes (TEN-E) have been created to facilitate investments in specific interconnections, while several network codes (e.g. grid connection codes) are currently being prepared. This will have a clear impact on PV systems generators when finally approved and adopted.

In addition, the question of the future of electricity markets is central in all electricity sector's discussions. The growing share of renewable energy suggests to rethink the way the electricity market in Europe is organized in order to accompany the energy transition in a sustainable way for new and incumbent players. Meanwhile, it has been made rather clear that the huge losses of several utilities in 2013 can rather be attributed to cheap lignite pushing gas out of the market and other similar elements rather than the impact of a few percent of PV electricity. While the role of PV was sometimes questioned due to the observed price decrease during the midday peak that is attributed to PV power production, it is absolutely not obvious whether this decrease during a limited number of hours every year really has an impact on the profitability of traditional utilities.

After more than a decade of rapid increase of production capacities (more than 100 GW of gas power plants have been connected to the grid since 2000), several utilities suffer from reduced operating hours and lower revenues due to these overcapacities in a stagnating market. The demand has hardly increased in the last decade in Europe.

Fearing for generation adequacy issues in the coming years due to gas power plants decommissioning, 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 certainty, the future of the electricity markets in Europe will be at the cornerstone of the development of PV.

The debate about the future of renewables grew again in 2013 and 2014 with the revision of the state-aid rules, through which the European Commission pushed Member States to shift incentives from FiTs to more market based instruments, including possible technology-neutral tenders. This recommendation has already been followed by several member states including Germany.

Finally, in order to answer complaints from European manufacturers, the Council of the European Union adopted final measures in the solar trade case with China in December 2013.

This decision confirms the imposition of anti-dumping and countervailing duties on imports into the European Union of crystalline silicon photovoltaic modules and cells originating from China. These duties, which are valid for a period of two years, will not apply retroactively.

Meanwhile, the acceptance of the undertaking offer submitted by China to limit the volumes and to set a threshold for prices has been accepted. The companies covered by this undertaking will be exempted from the general imposition of duties but will have to comply with minimum prices for modules and cells sold in Europe, within a certain volume.

## FINLAND

| | | |
|---|---|---|
| FINAL ELECTRICITY CONSUMPTION | 83 | TWh |
| HABITANTS | 5,4 | MILLION |
| IRRADIATION | 838 | kWh/kW |
| 2014 PV ANNUAL INSTALLED CAPACITY | 0 | MW |
| 2014 PV CUMULATIVE INSTALLED CAPACITY | 8 | MW |
| PV PENETRATION | 0,0 | % |

The official installation data for PV in Finland are not known yet at the time of writing these lines. The total capacity of grid-connected PV plants is estimated around 10 MW. However, during the year 2014 there were some visible signs that the market of grid-connected rooftop PV system is starting to grow in commercial and residential scales. There are no utility-scale PV plants in Finland. The off-grid PV market in Finland started in the 80's and has focused mainly on summer cottages and mobile applications. These systems are generally quite small size, typically less than 200 W.

There are some financial support schemes available for PV installations. The ministry of Employment and Economy grants investment support for the energy production. This energy support is particularly intended for promoting the introduction and market launch of new energy technology. So far, the Ministry has granted a 30% investment subsidy of the total costs of grid-connected PV projects. The total amount of financing reserved for all energy investment subsidies was around 80 MEUR in 2014. The decision for the investment subsidy is made case-by-case based on application. Only companies, communities and other organizations are eligible for the support. For the agricultural sector an investment subsidy for renewable energy production from the Agency of Rural Affairs is available as well. The subsidy covers 35% of the total investment. However, only the portion of the investment used in agricultural production is taken into account.

Self-consumption of PV electricity is allowed in Finland. However, there is currently no net-metering scheme available. An hourly-based net-metering for residential prosumers was under active discussion in mid-2015. Both the consumption and the generation of electricity is metered with the same energy meter owned by the DSO. Several energy companies offer two-way electricity (buying and selling) contracts for prosumers. Electricity generation below 100 kVA is exempted from the payment of electricity tax. The tax exemption is also valid for larger plants ranging from 100 kVA to 2 MVA if their annual electricity generation is below 800 MWh. The owning of a PV system is not regarded as a business activity in Finland. Individuals can produce electricity for their own household use without paying taxes. For individual persons, the income from the surplus electricity sales is considered as a personal income. However, individuals can subtract the depreciation and yearly system maintenance cost from the sales income. As a result in most cases the additional income from a rooftop PV system will not lead to additional taxes. Individuals can get a tax credit for the installation of the PV system on existing building. The amount covers 45% of the total work cost including taxes. The maximum tax credit for a person is 2 400 EUR/year and it is subtracted directly from the amount of taxes that have to be paid.

With these incentives, Finland could see some PV development in the coming years.

## FRANCE

| | | |
|---|---|---|
| FINAL ELECTRICITY CONSUMPTION | 465 | TWh |
| HABITANTS | 66 | MILLION |
| IRRADIATION | 1 100 | kWh/kW |
| 2014 PV ANNUAL INSTALLED CAPACITY | 939 | MW |
| 2014 PV CUMULATIVE INSTALLED CAPACITY | 5 678 | MW |
| PV PENETRATION | 1,3 | % |

France initially supported the PV development through a pure FiT scheme, paid for by residential electricity consumers. The objective of this policy was to give priority to supporting BIPV systems over conventional BAPV systems. Due to a surge in the demand at the end of 2010, the government decided to constrain the PV development to 800 MW a year. This new support framework was put in place in March 2011 after a moratorium. It still allows for systems of up to 100 kW to benefit from a FiT system. For systems larger than 100 kW, the FiT has decreased significantly to induce the development of very competitive projects. Alternatively, projects starting at 100 kW can apply to calls for tenders.

The added capacity in France went up to 939 MW in 2014, after having reached 1 119 MW in 2012 and 652 MW in 2013. A part of the added capacity has been realized in the overseas departments and territories of France: around 300 MW out of 5,7 GW. The rooftop market below 250 kW represented around 50% of added capacity in 2014, and systems above 250 kW, both rooftop and utility-scale, around 50%. In total utility-scale PV systems represented slightly less than 1,7 GW at the end of 2014. Off-grid installations in 2014 were around 0,05 MW while the total off-grid installed capacity is close to 30 MW. The support to BIPV explains the relatively high cost of support schemes in France. The local content premium has been cancelled.

## GERMANY

| | | |
|---|---|---|
| FINAL ELECTRICITY CONSUMPTION | 519 | TWh |
| HABITANTS | 81 | MILLION |
| IRRADIATION | 916 | kWh/kW |
| 2014 PV ANNUAL INSTALLED CAPACITY | 1 900 | MW |
| 2014 PV CUMULATIVE INSTALLED CAPACITY | 38 250 | MW |
| PV PENETRATION | 6,7 | % |

With three years in a row above 7 GW of PV systems connected to the grid, Germany installed at least 32 GW of PV systems until the end of 2012. 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.

In 2013 and 2014, the market went down to 3,3 GW then 1,9 GW, below the political will to frame the development of PV within a 2,4-2,6 GW range each year.

### Feed-in Tariff with a Corridor

The EEG law has introduced the FiT idea and has continued to promote it partially. It introduces a FiT for PV electricity that is mutualised in the electricity bill of electricity consumers. Exemption is applied to energy-intensive industries, a situation that was challenged by the European Commission in 2013. With the fast price decrease of PV, Germany introduced the "Corridor" concept in 2009: a method allowing the level of FiTs to decline according to the market evolution. The more the market grows during a defined period of time, the lower the FiT levels are. 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 latest change has been put in place since August 2014.

In September 2012, Germany abandoned FiT for installations above 10 MW in size and continued to reduce FiT levels in 2013 and 2014.

### 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%. On the 1st April 2012, the premium was cancelled when FiT levels went below the retail electricity prices. With the same idea, for systems between 10 kW and 1 MW, a cap was set at 90% in order to force self-consumption. If the remaining 10% has to be injected anyway, a low market price is paid instead of the FiT.

Since August 2014, 30% of the surcharge for renewable electricity will have to be partially paid by prosumers for the self-consumed electricity for systems above 10 kW.

A newly installed programme of incentives for storage units was introduced 1st May 2013, which aims at increasing self-consumption and reducing the share of FiT-driven PV in Germany. This programme financed 8 300 battery storage systems installed in Germany by the end of 2014.

### Market Integration Model

In contrast 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

## EUROPE / CONTINUED

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. This system will become compulsory for all new installations above 100 kW in 2016.

### 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 is not remotely controlled by the grid operator.

## ITALY

| | | |
|---|---|---|
| FINAL ELECTRICITY CONSUMPTION | 308 | TWh |
| HABITANTS | 61 | MILLION |
| IRRADIATION | 1 326 | kWh/kW |
| 2014 PV ANNUAL INSTALLED CAPACITY | 424 | MW |
| 2014 PV CUMULATIVE INSTALLED CAPACITY | 18 622 | MW |
| PV PENETRATION | 8,0 | % |

Implemented since 2005, the “Conto Energia” scheme has allowed an increasing market development, resulting in a boom in installations in 2010 and 2011 and connections to the grid in 2011 and 2012. It was closed in July 2013, once the financial cap set by Italian authorities for the total yearly incentive cost at 6,7 BEUR was reached.

### A Capped Cost for PV Financial Support

Italy had made the choice to develop the PV market with different mechanisms; starting from 2000 with a net-metering scheme together with a direct incentive program. Then from 2005, the FiT (the so-called “Conto Energia”) was initiated. In 2008, a self-consumption regulation was introduced (the first version of the “Scambio Sul Posto”). The cost of the FiT for PV electricity was mutualised in the electricity bill of electricity consumers and was subjected to a cap. Since the FiT was not active anymore since 2013, tax credit was the remaining measure used in Italy (available only for small size plants up to 20 kW) together with a net-billing scheme.

Italy installed 424 MW during the year 2014 including 65 MW of ground-mounted and 23 MW of BIPV plants. 20% of 2014 installations were still linked to the past FiT scheme while the 80% remaining were installed with the tax incentive and/or the self-consumption scheme. In total, more than 18,6 GW of PV systems were operational in Italy at the end of 2014. This represents 2,7 GW of BIPV (of which 280 MW of innovative BIPV) and 7,2 GW of BAPV systems. On the whole, 11,2 GW of centralized systems and 30 MW of CPV have benefited from targeted incentives.

In November 2014, the government decided to modify the FiT conditions for existing plants above 200 kW. Plant owners were invited to select between the following options:

- Reduced FiT paid during the foreseen 20 years, depending on plant size;
- Maintain the cumulative 20 years FiT incentives but paid during 24 years;
- Reduced FiT paid during 20 years but with an increase in the last period.

### 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 (increased to 500 kW for plants commissioned in 2015). 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.

In addition, the management of one or more PV systems directly connected from the producer to the final consumer (the so-called SEU scheme) has been properly regulated in 2014.

Finally new rules for electricity storage connected to the grid were published in December 2014.

### Comments

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 is the country that incentivized BIPV systems the most (in terms of volume).

## NETHERLANDS

| | | |
|---|---|---|
| FINAL ELECTRICITY CONSUMPTION | 111 | TWh |
| HABITANTS | 17 | MILLION |
| IRRADIATION | 950 | kWh/kW |
| 2014 PV ANNUAL INSTALLED CAPACITY | 400 | MW |
| 2014 PV CUMULATIVE INSTALLED CAPACITY | 1 123 | MW |
| PV PENETRATION | 1,0 | % |

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 FiT 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 220 MW installed in the country, pushing the installed capacity up to 365 MW. In 2013, 360 MW were installed and the total capacity at the end of the year reached 723 MW. In 2014, the market reached the GW mark and around 400 MW were installed.

The main incentive for households is now net-metering which was before limited to 5 000 kWh for each connection but as of 2014 this upper boundary was removed and net-metering is now guaranteed until 2020.

A reverse auctioning system exists for large-scale PV systems but so far it has failed to attract massively PV developers.

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

| | | |
|---|---|---|
| FINAL ELECTRICITY CONSUMPTION | 126 | TWh |
| HABITANTS | 5 | MILLION |
| IRRADIATION | 800 | kWh/kW |
| 2014 PV ANNUAL INSTALLED CAPACITY | 2 | MW |
| 2014 PV CUMULATIVE INSTALLED CAPACITY | 13 | MW |
| PV PENETRATION | 0,0 | % |

The PV market in Norway grew significantly in 2014 but at a very low level. A total of approximately 2,2 MW of PV power was installed during 2014. 1,4 MW were grid-connected and 0,8 MW were off-grid systems. The total installed capacity reached 12,8 MW at the end of 2014.

The off-grid market refers to both the leisure market (cabins, leisure boats) and the professional market (primarily lighthouses/lanterns along the coast and telecommunication systems).

Self-consumption is allowed for residential plants under the "Plus-customer scheme" (Plusskundeordningen) provided that the customer is a net consumer of electricity on a yearly basis. The Plus-customer scheme is under revision at the moment and a new, possibly compulsory scheme, is expected to be implemented in the near future.

## PORTUGAL

| | | |
|---|---|---|
| FINAL ELECTRICITY CONSUMPTION | 49 | TWh |
| HABITANTS | 10 | MILLION |
| IRRADIATION | 1 500 | kWh/kW |
| 2014 PV ANNUAL INSTALLED CAPACITY | 110 | MW |
| 2014 PV CUMULATIVE INSTALLED CAPACITY | 391 | MW |
| PV PENETRATION | 1,2 | % |

Around 110 MW were installed in Portugal in 2014, bringing the total installed capacity to around 391 MW. The market has been mostly driven by the FiT scheme. 88 MW installed in 2014 were still under the scope of the Independent Power Producer (IPP) scheme. The remaining installations occurred under the two other schemes: the micro-generation (below 5 kW) and the mini-generation schemes (up to 250 kW), most of which are commercial or industrial rooftop systems. These schemes were cancelled at the end of 2014.

A new framework oriented for self-consumption systems, with and without power injection in the public grid, will replace the former frameworks (IPP, micro and mini-generation) in 2015.

In 2013, given the difficult financial situation of the country, the government decided to revise targets under the National Renewable Energy Action Plan for 2020 and the official goal for PV was reduced from 1,5 GW to 720 MW in 2020.

## SPAIN

| | | |
|---|---|---|
| FINAL ELECTRICITY CONSUMPTION | 223 | TWh |
| HABITANTS | 46 | MILLION |
| IRRADIATION | 1 600 | kWh/kW |
| 2014 PV ANNUAL INSTALLED CAPACITY | 22,6 | MW |
| 2014 PV CUMULATIVE INSTALLED CAPACITY | 5 376 | MW |
| PV PENETRATION | 3,8 | % |

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 in 2009, due to the necessary time to put the new regulation in place, the market went down to between 100 and 450 MW a year. In 2012 the Spanish Government established a new moratorium for all the renewables projects with FiT. In 2014, 22 $MW_{AC}$ (around 22,6 $MW_{DC}$) were installed in Spain and the total installed capacity tops more than 4,8 $GW_{AC}$ (5,4 $GW_{DC}$).

### Capped Retail Electricity Prices

Spain chose to finance the FiT costs by mutualising them on all electricity consumers, as many other countries have done. In addition, Spain caps the price of retail electricity and in case of a difference with the generation costs, the deficit is finally paid by electricity consumers. The cumulated deficit of such a policy amounts now to 34 BEUR and it is estimated that the cost of renewables paid by electricity consumers has contributed to around 25% of this amount. In order to reduce this deficit, retroactive measures have been taken to reduce the FiTs already granted to renewable energy sources.

Some measures were taken that have affected retroactively PV electricity producers. 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

# EUROPE / CONTINUED

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. Since then, several taxes and retroactive measures took place in order to reduce the amount of money paid to PV producers.

In the summer of 2013, the Government announced a new reform of the electricity market. Under the 24/213 Power Sector Act, the FiT system was stopped in July 2013 and the new schemes are based on the remuneration of capacities rather than production. The new system is based on estimated standard costs, with a legal possibility to change the amounts paid every four years. This has caused many projects to be in a state of default.

The 24/2013 Power Sector Act considers very restrictive forms of self-consumption but in 2014 no piece of regulation was adopted to offer a suitable regulatory framework for net-metering.

Discussions were ongoing in 2014 to allow self-consumption, under a constraining framework and especially additional fees that would make self-consumption hardly competitive. So far this framework has not been adopted formally and self-consumption with no compensation for the excess PV electricity injected into the grid is allowed below 100 kW. In any case, the release of this draft had the effect of stopping the market. In the year 2014, only 22,6 $MW_{DC}$ were installed. 75,2% of this new capacity are off-grid projects, outside of the proposed self-consumption regulation under discussion.

In July 2015 the government started the procedure to approve a new draft that could include a so-called "sun tax".

## SWEDEN

| | | |
|---|---|---|
| FINAL ELECTRICITY CONSUMPTION | 136 | TWh |
| HABITANTS | 10 | MILLION |
| IRRADIATION | 950 | kWh/kW |
| 2014 PV ANNUAL INSTALLED CAPACITY | 36 | MW |
| 2014 PV CUMULATIVE INSTALLED CAPACITY | 79 | MW |
| PV PENETRATION | 0,1 | % |

The PV power installation rate in Sweden continued to increase in 2014 for the 4th year in a row and a total of 36,2 MW was installed.

The off-grid market remained stable at 1,1 MW. As in 2013, 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 18 MW were installed in 2013. The strong growth in the Swedish PV market is mainly due to lower module prices, and a growing interest in PV.

Grid-connected capacity almost reached 70 MW cumulative while the off-grid capacity established itself at 9,5 MW at the end of 2014.

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 seven years, more grid-connected capacity than off-grid capacity has been installed and grid-connected PV largely outscores off-grid systems. The grid-connected market is almost exclusively made up of roof mounted systems installed by private persons or companies. So far, centralized systems have started to develop at a very low level (2,8 MW installed in 2014).

### 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 MSEK for the years 2013-2016. These funds were completely used in 2014 already, which pushed the government to add 50 MSEK for 2015.

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

Net-metering has been discussed and investigated several times but it has not yet been introduced. In the meantime, some utilities have decided to put different compensation schemes in place. Self-consumption through net-metering is one example of these kind of schemes.

Additionally, a tradable green certificates scheme exists since 2003, but only around less than 20 MW of PV installations are using it so far, because of the insufficient level of support for solar PV installations.

## SWITZERLAND

| | | |
|---|---|---|
| FINAL ELECTRICITY CONSUMPTION | 58 | TWh |
| HABITANTS | 8 | MILLION |
| IRRADIATION | 995 | kWh/kW |
| 2014 PV ANNUAL INSTALLED CAPACITY | 305 | MW |
| 2014 PV CUMULATIVE INSTALLED CAPACITY | 1 061 | MW |
| PV PENETRATION | 1,8 | % |

305 MW were connected to the grid in Switzerland in 2014, a similar level compared to 2013 (319 MW). Almost 100% of the market consists of rooftop applications and the few ground mounted PV applications are very small in size. Large-scale ground mounted is almost non-existent in Switzerland. More than 1 GW of grid-connected applications are producing electricity in the country in addition to approximately 4 MW of off-grid applications.

This was achieved in 2014 thanks to a decrease of the FiTs levels, in line with the PV system cost decrease, that allowed for raising the FiT-cap on installations.

Besides the (capped) national FiT scheme there are still many regional, local and utility support schemes. These are either based on direct subsidies or FiTs equal or below the federal level. In 2014, a new federal direct subsidy scheme entered into force for systems below 30 kW. Since it is not capped, it attracted many potential prosumers awaiting the FiT. Since 2014, systems below 10 kW are not eligible anymore for the FiT.

Self-consumption is allowed since 2014 and can be considered as profitable under condition of a high self-consumption ratio.

The FiT is financed through a levy on electricity prices.

BAPV represented 75% of the market in 2014, with BIPV around 25% thanks to an extra category in the FiT scheme.

The system 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 FiT scheme that allows covering the entire roof rather than delivering the same amount of electricity as the yearly consumption. The current schemes also allow 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, is being perceived as a potential source of electricity to be developed. 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.

## OTHER COUNTRIES

2,4 GW of PV systems have been installed in 2014 in the United Kingdom (UK), bringing the total installed capacity to 5,3 GW. The UK was the first European market in 2014, ahead of Germany.

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 than retail electricity prices (up to 0,14 GBP/kWh). Above 30 kW, excess electricity is sold on the electricity market.

For larger systems, the 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 will be replaced in 2015 for systems above 5 MW 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 experienced a very fast PV market boom in 2012 that was fuelled by relatively high FiTs. Officially 1 GW 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 FiTs, Bulgarian grid operators have opted for additional grid fees in order to limit market development. The consequence is that the market went down to 10 MW in 2013 and 2 MW in 2014.

In the Czech Republic, driven by low administrative barriers and a profitable FiT scheme, the Czech PV market boomed in 2009 and especially in 2010. With more than 2 GW installed, 46 MW of installations occurred in 2013 in the country and less than 2 MW in 2014. Composed mainly of large utility-scale installations, the Czech PV landscape left little place to residential rooftop installations that are now the only installations that could benefit from a FiT system until 2013.

After having installed 912 MW in 2012, Greece installed 1,04 GW of PV systems in 2013, and reached 2,6 GW of installed capacity. Since then the market went down to 17 MW in 2014. The market was driven by FiTs that were adjusted downwards several times. The installations are mainly concentrated in the rooftop segments (commercial and industrial segments in particular). With dozens of islands powered by diesel generators, the deployment of PV in the Greek islands went quite fast in 2012 and 2013. 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.

Romania experienced a rapid market development with 1,1 GW installed in one year, driven by an RPS system with quotas paid during 15 years. Financial incentives can be granted but reduce the amount of green certificates paid. In 2014, the government decided to freeze 2 out of 6 green certificates until 2017 in order to limit the decline of the green certificates price on the market. In addition, the number of green certificates granted for new PV installations went down to 3. Romania illustrates the case of an RPS system with Green Certificates where the level of the RPS was not adjusted fast enough to cope with the growth of installations.

Other European countries have experienced some market development in 2014, most of the time driven by FiT schemes. Poland has installed 30 MW for the first time in 2014. A mix of FiTs, self-consumption measures and calls for tenders are now in place. Slovakia experienced very fast market development in 2011 with 321 MW installed but less than 1 MW with reduced incentives and a rather negative climate towards PV investments in 2014. Ukraine has seen a spectacular market development from 2011 to 2013 with 616 MW of large installations. However, the political instability will have long term impacts on the PV development in the country and no installations were connected in 2014.

In total, the European markets represented 7,0 GW of new PV installations and 89 GW of total installed capacity in 2014.

# MIDDLE EAST AND AFRICA

Despite excellent solar irradiation conditions, few countries had yet to step into PV development before 2014. However several countries are defining PV development plans and the prospects on the short to medium term are positive.

## ISRAEL

| | | |
|---|---|---|
| FINAL ELECTRICITY CONSUMPTION | 49 | TWh |
| HABITANTS | 8 | MILLION |
| IRRADIATION | 1 450 | kWh/kW |
| 2014 PV ANNUAL INSTALLED CAPACITY | 200 | MW |
| 2014 PV CUMULATIVE INSTALLED CAPACITY | 681 | MW |
| PV PENETRATION | 2,0 | % |

In 2014, Israel installed roughly 200 MW of new PV systems, following 244 MW in 2013, 47 MW in 2012 and 120 MW in 2011.

In December 2014 a first utility-scale system was connected to the transmission grid (37,5 MW). Most of the new installations continued to be medium size: between 500 kW to several MW with connection to the distribution grid. In the next two years, additional PV power is expected to come mostly from large plants installation. The capacity factor for PV in Israel is considerably higher than in Europe and stands around 19% for actual production on an annual average. The penetration of single axis tracking systems is increasing due to the higher capacity factor, standing at around 24%.

Due to the scarcity of land, efforts are being made to develop PV systems as a secondary land usage. In addition to the obvious rooftop solution, the option of using water reservoirs, and waste land is being tested also the use on the same plot of land with some types of agriculture. Tracking systems are particularly fit for this, as the spacing between the panels is larger.

In total, more than 600 MW of PV systems were operational in Israel at the end of 2014.

Government support is given in the form of guaranteed FiT for 20 years. FiTs vary by project nature, size and other parameters. FiT have decreased considerably over the last few years, and are expected to continue their decline. Current FiT for PV systems range from 0,38 to 0,6 NIS (0,1 to 0,15 USD).

Because FiT includes a subsidy, which is paid by the electricity consumer, there are quotas (Caps) for each renewable energy category. In 2014 an additional quota of 340 MW for PV was issued, to be evenly spread during 2015-2017. This quota comes mostly at the expense of Biomass electricity production, for which it was decided that the original targets were too high, due to lack of source material. In addition there is a quota of 180 MW, which is expected to be converted from CSP to PV. These steps are taken, in order to achieve the goal of 10% RE production by 2020, and in consideration with the fact that PV is currently the most readily available renewable energy source in Israel.

It is now clear that PV systems are close to grid parity in Israel. A tariff has been set up for PV developers: this tariff is the recognized conventional electricity generation tariff + a premium for emissions reduction (currently 0,30 + 0,08 NIS respectively). This tariff is not subject to the FiT quotas. The main issue for PV developers now, is the fact that the rate fluctuates with conventional electricity generation rates, and is thus not guaranteed. In fact generation costs of fossil based electricity have been steadily declining, mainly due to the sharp decrease in the price of coal.

### Net-Metering/Self-Consumption

- In 2013, a net-metering scheme was implemented for all RE sources. It established a cap of 200 MW for 2013 and the same for 2014. This was extended to 2015, and is expected to be further extended. This quota is applicable to all renewable generation up to 5 MW.
- Real-time self-consumption simply reduces the electricity bill.
- Excess PV production can be fed into the grid in exchange for monetary credits, which can be used to offset electricity consumption from the grid during the following 24 months. The credit is time of day dependent. Thus a small overproduction at peak times, can offset a large consumption at low times.
- Credits can be transferred to any other consumer and in particular to other locations of the same entity.
- One has the option to sell a preset amount of the electricity to the grid for money (and not credit), but at a conventional manufacturing price (currently 0,30 NIS/kWh).
- All the electricity fed into the grid is subject to Grid and Services charges.
- A back-up fee that aims to cover the need to back-up PV systems with conventional power plants will be imposed, when the installed capacity will reach 1,8 GW. This fee is technology dependent and will grow for solar from 0,03 NIS/kWh to 0,06 NIS/kWh after 2,4 GW will be installed.
- A balancing fee (0,015 NIS/kWh) for variable renewable sources has also been introduced.
- Finally, a grid fee that depends on the time of day and day of the week and connection type (to transmission, distribution, or supply grid) has been introduced and ranges between 0,01 NIS/kWh and 0,05 NIS/kWh.

## TURKEY

| | | |
|---|---|---|
| FINAL ELECTRICITY CONSUMPTION | 156 | TWh |
| HABITANTS | 76 | MILLION |
| IRRADIATION | 1 527 | kWh/kW |
| 2014 PV ANNUAL INSTALLED CAPACITY | 40 | MW |
| 2014 PV CUMULATIVE INSTALLED CAPACITY | 58 | MW |
| PV PENETRATION | 0,1 | % |

The PV market remained very low in Turkey until 2013 but started to develop in 2014 with 40 MW installed.

Solar PV can now benefit from two different ways of developing PV projects: with or without a license for production.

In the first license application round, launched in June 2013, 600 MW PV projects, larger than 1 MW, should have been approved. However, at the end of 2014 only 13 MW got the licence and the right to build.

The rest of the 600 MW received the pre-licenses following the competition process driven by Turkish Electricity Transmission Company (TEİAŞ) in the first quarter of 2015.

Unlicensed projects are limited to 1 MW. Only the unlicensed PV plants had been installed in Turkey until the end of 2014. Given the complexity of the process in the past, some investors preferred to setup MW scaled PV plants unlicensed.

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)

Cumulative grid-connected installed PV power in Turkey by the end of 2014 is estimated at about 58 MW and 2015 is expected to be a critical year for the development of PV in Turkey.

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

## OTHER COUNTRIES

South Africa became the first African PV market in 2014 with around 922 MW installed, mostly ground mounted.

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 has been closed in 2013 and a fourth one was hold in 2015.

In MEA (Middle East and Africa) 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. The fastest mover is Egypt, which has announced plans to develop PV. A FiT program targets 2,3 GW of installations (G2 between 50 kW and 50 MW) and 300 MW below 50 kW. In addition, 5 GW of projects have been signed in 2015 for installation before 2020.

In Morocco, PV could play a small role next to CSP.

In Algeria, a new FiT scheme has been set up in 2014 for ground-mounted systems above 1 MW. In addition, 400 MW have been planned.

In several African countries, the interest for PV is growing, while the market has not really taken off yet. At least large-scale plants are planned in several countries to replace or complement existing diesel generators, from 1,5 to 155 MW in size; these plants are planned in Ghana, Mali, Ivory Coast, Burkina Faso, Cameroon, Gambia, Mauritania, Benin, Sierra Leone and more.

In 2014, Nigeria signed a memorandum to install at least 1,2 GW of PV in the coming years.

In Rwanda, a 8,5 MW plant has been inaugurated at the beginning of 2015.

Winning bids in tenders in Dubai and Jordan have reached extremely low levels around 0,06 USD/kWh. Dubai will install 200 MW in the coming years and more have been announced. Jordan at one time announced 200 MW, then that it aimed for at least 1 GW of PV in 2030 with 13 MW being built in 2013. Qatar launched its first tender for 200 MW in October 2013.

Other countries in the Middle East have set up plans for PV development at short or long term. Lebanon has set up a FiT and Saudi Arabia has made plans for PV development which have been delayed in 2014.

## MIDDLE EAST AND AFRICA / CONTINUED

The *Desertec* project, aiming at providing solar electricity from Middle East and Northern Africa (MENA) to Europe pushed to adapt national frameworks and demo projects in several countries in the MENA region. Meanwhile, the evolution of the electricity demand in the region shifts away the moment when it will be able to really export to Europe. The previously-called "Desertec Industrial Initiative", renamed "DII" was working to open markets for PV in the region, in an attempt to accelerate the development of renewables, including PV and to set up the right framework that will allow in the future cross-continent electricity delivery. In 2014, the project was reframed to "desert power" and moved to Dubai, abandoning the idea to produce for export.

### TABLE 2: PV INSTALLED CAPACITY IN OTHER MAIN COUNTRIES IN 2014

| COUNTRY | ANNUAL CAPACITY 2014 (MW) | CUMULATIVE CAPACITY 2014 (MW) |
|---|---|---|
| UK | 2 442 | 5 272 |
| SOUTH AFRICA | 800 | 922 |
| INDIA | 779 | 3 046 |
| CHILE | 395 | 402 |
| TAIWAN | 223 | 615 |
| ROMANIA | 72 | 1 230 |
| ECUADOR | 64 | 64 |
| POLAND | 31 | 38 |
| PHILIPPINES | 30 | 33 |
| INDONESIA | 20 | 79 |

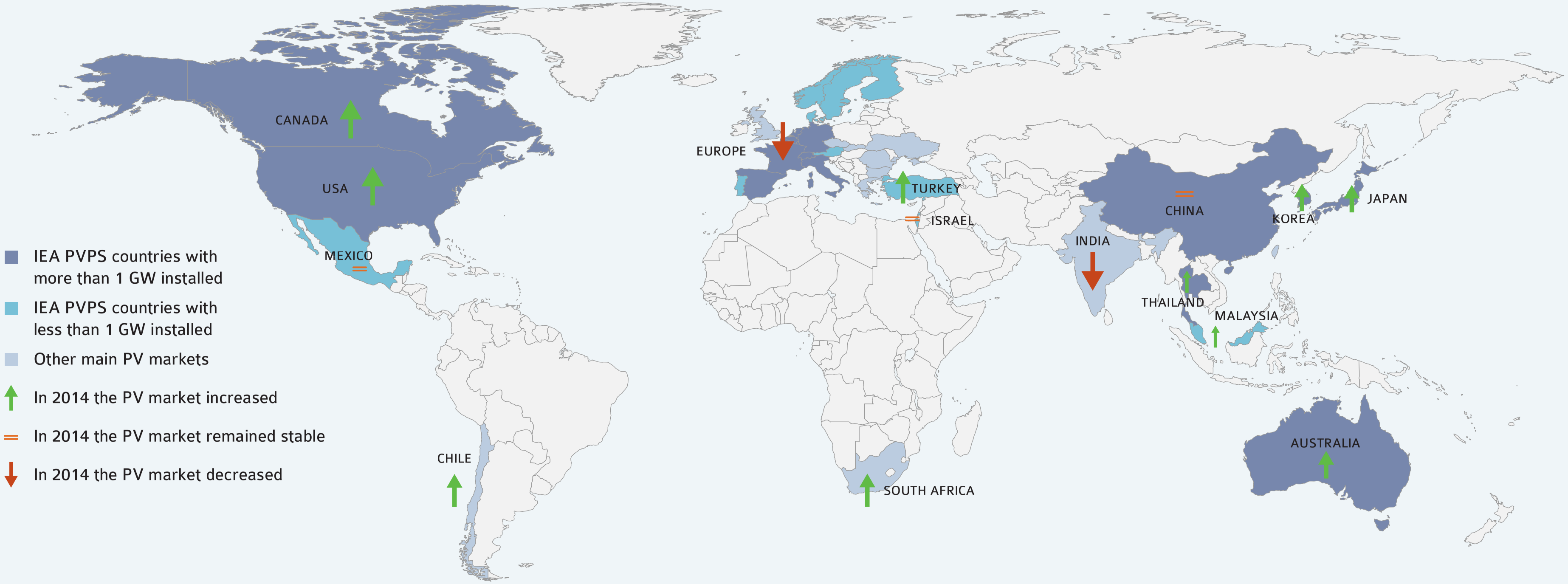
SOURCE IEA PVPS.

### TABLE 3: 2014 PV MARKET STATISTIC IN DETAIL

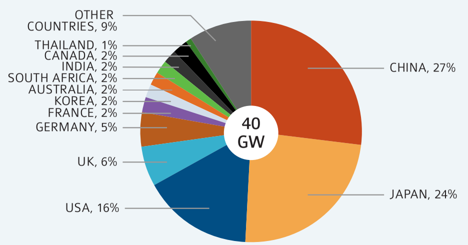
| COUNTRY | 2014 ANNUAL CAPACITY (MW) | | | | | 2014 CUMULATIVE CAPACITY (MW) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | GRID-CONNECTED | | OFF-GRID | | | GRID-CONNECTED | | OFF-GRID | | |
| | DECENTRALIZED | CENTRALIZED | DOMESTIC | NON-DOMESTIC | TOTAL | DECENTRALIZED | CENTRALIZED | DOMESTIC | NON-DOMESTIC | TOTAL |
| AUSTRALIA | 805 | 83 | 13 | 3 | 904 | 3 875 | 107 | 87 | 61 | 4 130 |
| AUSTRIA | 159 | 0 | 0 | 0 | 159 | 780 | 2 | 5 | 0 | 787 |
| BELGIUM | 79 | 0 | 0 | 0 | 79 | 2 508 | 648 | 0 | 0 | 3 156 |
| CANADA | 142 | 491 | 0 | 0 | 633 | 415 | 1 428 | 23 | 38 | 1 904 |
| CHINA | 2 050 | 8 550 | 40 | 0 | 10 640 | 5 130 | 22 892 | 308 | 0 | 28 330 |
| DENMARK | 39 | 3 | 0 | 0 | 42 | 596 | 8 | 1 | 1 | 606 |
| FINLAND | NA | NA | NA | NA | NA | 8 | 0 | 0 | 0 | 8 |
| FRANCE | 601 | 338 | 0 | 0 | 939 | 3 968 | 1 680 | 30 | 0 | 5 678 |
| GERMANY | 1 289 | 611 | 0 | 0 | 1 900 | 28 359 | 9 841 | 50 | 0 | 38 250 |
| ISRAEL | 60 | 140 | 0 | 0 | 200 | 417 | 260 | 4 | 0 | 681 |
| ITALY | 359 | 65 | 0 | 0 | 424 | 7 369 | 11 241 | 0 | 12 | 18 622 |
| JAPAN | 6 589 | 3 150 | 0 | 1 | 9 740 | 18 294 | 4 990 | 9 | 116 | 23 409 |
| KOREA | 109 | 800 | 0 | 0 | 909 | 379 | 2 014 | 1 | 5 | 2 398 |
| MALAYSIA | 87 | 0 | 0 | 2 | 88 | 162 | 0 | 0 | 6 | 168 |
| MEXICO | 32 | 35 | 0 | 0 | 67 | 72 | 82 | 19 | 6 | 179 |
| NETHERLANDS | 400 | 0 | 0 | 0 | 400 | 1 115 | 8 | 0 | 0 | 1 123 |
| NORWAY | 1 | 0 | 0 | 1 | 2 | 2 | 0 | 10 | 1 | 13 |
| PORTUGAL | 0 | 110 | 0 | 0 | 110 | 134 | 253 | 4 | 0 | 391 |
| SPAIN | 6 | 0 | 4 | 13 | 23 | 3 065 | 2 202 | 32 | 78 | 5 376 |
| SWEDEN | 32 | 3 | 1 | 0 | 36 | 65 | 5 | 9 | 1 | 79 |
| SWITZERLAND | 305 | 0 | 0 | 0 | 305 | 1 055 | 3 | 3 | 0 | 1 061 |
| THAILAND | 37 | 438 | 0 | 0 | 475 | 37 | 1 231 | 0 | 30 | 1 299 |
| TURKEY | 5 | 35 | 0 | 0 | 40 | 12 | 46 | 0 | 0 | 58 |
| USA | 2 277 | 3 934 | 0 | 0 | 6 211 | 8 573 | 9 744 | 0 | 0 | 18 317 |
| TOTAL IEA PVPS | 15 463 | 18 785 | 59 | 21 | 34 328 | 86 389 | 68 683 | 595 | 357 | 156 023 |
| NON IEA PVPS COUNTRIES | | | | | 4 958 | | | | | 19 352 |
| REST OF THE WORLD ESTIMATES | | | | | 554 | | | | | 1 628 |
| TOTAL | | | | | 39 839 | | | | | 177 003 |

SOURCE IEA PVPS.

# TRENDS 2015 177 GW OF PV INSTALLED IN THE WORLD IN 2014




40 GW USA 6,2 GW 1% of the Electricity demand UK 6% PV penetration in 3 countries 177 GW India Japan 9,7 GW China 10,6 GW Australia Korea 58,5 USD/MWh Dubai Lowest Bid 85 BUSD economic value South Africa 46 GW produced 55% Centralised Germany 60% Asia 27% PV in Total RES France 75% cells and modules from Asia





EVOLUTION OF TOP 10 PV MARKETS

| RANKING | 2012 | 2013 | 2014 |
|---|---|---|---|
| 1 | GERMANY | CHINA | CHINA |
| 2 | ITALY | JAPAN | JAPAN |
| 3 | USA | USA | USA |
| 4 | CHINA | GERMANY | UK |
| 5 | JAPAN | ITALY | GERMANY |
| 6 | FRANCE | UK | FRANCE |
| 7 | AUSTRALIA | ROMANIA | KOREA |
| 8 | INDIA | INDIA | AUSTRALIA |
| 9 | GREECE | GREECE | SOUTH AFRICA |
| 10 | BULGARIA | AUSTRALIA | INDIA |
| MARKET LEVEL TO ACCESS THE TOP 10 | | | |
| | 843 MW | 811 MW | 779 MW |

SOURCE IEA PVPS.

WITH 40 GW, THE MARKET GREW IN 2014 BY 4,2 % THE HIGHEST INSTALLATION EVER FOR PV WITH CHINA, JAPAN AND USA LEADING THE WAY.


PV system on rooftop in Queens, NY. © Solar Energy Systems / NREL

# three

# POLICY FRAMEWORK

**PV development 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 over the last ten years. These support schemes took various forms depending on the local specificities and evolved to cope with unexpected market evolution or policy changes.**

In 2014, the price of PV systems, as we have seen, and accordingly the cost of producing electricity from PV (LCOE) continued to drop to levels that are in some countries close or even below the retail price of electricity (the so-called "grid parity") or in some cases close to the wholesale 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 most cases cheaper than producing it with a diesel generator.

But PV systems are not yet fully competitive in all markets and segments and the development of PV still requires adequate support schemes as well as 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 2014

Figure 11 shows that about only 3,7% of the world PV market has been driven by pure self-consumption or the sole competitiveness of PV installations in 2014. It also means 96,3% of the global PV market depends on support schemes.

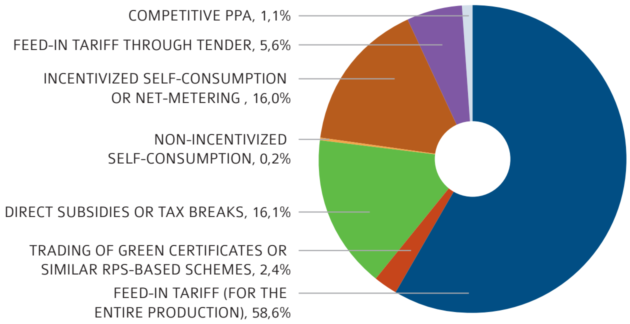
In 2014 a large part of the market remained dominated by FiT schemes (more than 63%) granted with or without a tender. Subsidies aiming at reducing the upfront investment (or tax breaks) represent around 16% of the incentives. Incentivised self-consumption including net-billing and net-metering was the main incentive in 2014 for 16% of the world market. Various forms of incentivized self-consumption schemes exist (and are often called improperly net-metering), such as Italy with the Scambio Sul Posto, Israel, or Germany.

Historically, the dominance of FiTs and direct subsidies is similar but even more visible in Figure 11.

The emergence of calls for tenders has been confirmed again in 2014, with new countries using this legal tool to attribute remunerations to PV projects under certain conditions. Germany, Dubai (UAE), Jordan and many others have joined the list of countries using calls for tenders to grant PPAs for PV plants. The result of these calls for tenders is a guaranteed payment for PV electricity, or in other words, a FiT. Such tenders represented around 5,6% of the world market in 2014 and is increasing.

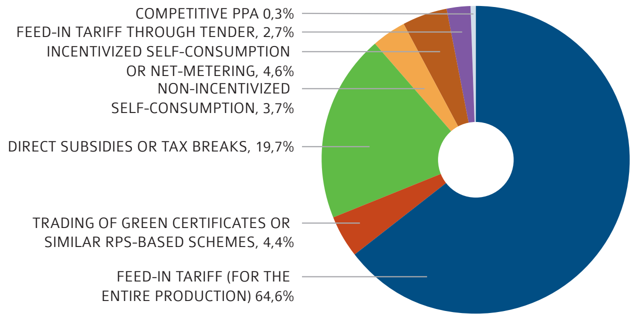
Incentives can be granted by a wide variety of authorities or sometimes by utilities themselves. They can be unique or add up to each other. Their lifetime is generally quite short, with frequent policy changes, at least to adapt the financial parameters. Next to

**FIGURE 10:** 2014 MARKET INCENTIVES AND ENABLERS




SOURCE IEA PVPS.

**FIGURE 11:** HISTORICAL MARKET INCENTIVES AND ENABLERS




SOURCE IEA PVPS.

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, generally in the absence of national or local incentives, but sometimes to complement them.

## COST OF SUPPORT SCHEMES

The cost of the FiT or similar incentives 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-come first-served principle is applied (Austria, Switzerland). Most countries did not impose a yearly cap on FiT expenditures, which led to fast market development in Germany, Italy, Spain and many others.

Some examples:

Denmark: the PSO (Public Service Obligation) covers RE remuneration costs in addition to other related subjects. It amounts to 0,21 DKK/kWh and the total cost amounted to 7,1 BDKK in 2014. It is paid by electricity consumers.

France: The CSPE surcharge part for PV amounted to 2,2 BEUR in 2014, or around 1,65 EURcts/kWh. It represented around 15% of the residential consumers' electricity bill.

Germany: The EEG surcharge that covers the cost of all renewable sources is paid by all electricity consumers, with an exemption for large industrial consumers. Since 2014, some prosumers are paying a part of the surcharge on the self-consumed PV part. The surcharge amounted to 6,24 EURcts/kWh in 2014, including around 2 EURcts/kWh for PV.

Italy: around 3,6 EURcts/kWh are paid by the electricity consumers in the residential sector (including around 2 EURcts/kWh for PV) and smaller amount by others final electricity users. The total annual cost amounts to 12,5 BEUR for all RES including 6,7 BEUR for PV.

Japan: two surcharges are in place, depending on the FiT program. They represented around 2,4% to 3,2% of the bill in 2014.

Malaysia: consumers above 300 kWh/month are paying a surcharge for the RE Fund that finances the FiT. It represented around 16% of the electricity price paid by retail consumers in 2014.

Spain: the surcharge is estimated for all renewables around 2,4 EURcts/kWh for residential consumers and around 1,1 EURcts/kWh for industrial ones.

USA: the ITC tax break is borne by the federal budget indirectly (since the budget is not used but it represents rather a decrease of the potential income from PV development costs).

## 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 China, Germany, Italy (until 2013) and Japan, to mention a few. The attractiveness of FiT has been slightly reduced but they still drive a large part of the PV market.

### 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 and Switzerland), outside of the policy framework.

## MARKET DRIVERS IN 2014 / CONTINUED

### Market Control Systems

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 over the last years, the profitability of PV investments grew very quickly when the level of the FiT was not 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.

The "corridor" principle has been experimented in Germany since 2011 and was 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 and 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 France for some market segments (above 250 kW) and in 2015 Germany will first use it for utility-scale plants. Many countries around the world are now using it as a way to control the grants. 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 now and Spain in the past) or simply an administrative procedure. It can be used to promote specific technologies (e.g. CPV systems in France) or impose additional regulations to PV system developers. It can be technology specific (Germany, France, South Africa, etc.) or technology neutral (the Netherlands, Poland). In this last case, PV is put in competition with other generation sources, with little success until now. Tenders have been set up in emerging PV markets with record results in India, Jordan or the UAE.

### 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 4 to 8 USDcents in 2014), 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 2008 Scambio Sul Posto system.

**TABLE 4:** THE MOST COMPETITIVE TENDERS IN THE WORLD IN 2014 AND 2015

| REGION | COUNTRY/STATE | USDCENTS/KWH |
|---|---|---|
| MIDDLE EAST | DUBAI | 5,85 |
| MIDDLE EAST | JORDAN | 6,13 |
| NORTH AMERICA | TEXAS | 7,50 |
| SOUTH AFRICA | SOUTH AFRICA | 7,60 |
| LATIN AMERICA | BRAZIL | 8,10 |
| INDIA | INDIA | 8,75 |
| CENTRAL AMERICA | PANAMA | 9,00 |
| WESTERN EUROPE | GERMANY | 10,06 |

SOURCE IEA, BECQUEREL INSTITUTE.

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.

### Feed-in Premium

In several countries, the FiT schemes are being replaced by feed-in premiums. The concept behind the premium is to be paid in addition to the electricity market price. Fixed and variable premiums can be considered. In Germany, the "direct marketing" of solar PV electricity is based on a Feed-in Premium (FiP) that is paid on top of the electricity wholesale market price in order to allow a remuneration slightly higher than the FiT, including a management premium. In the UK, the Contract for Difference scheme can be seen as a FiP that ensures a constant remuneration by covering the difference between the expected remuneration and the electricity market price.

## UPFRONT INCENTIVES

PV is by nature a technology with limited maintenance costs, no fuel costs but has a high upfront investment need. This has led some countries to put policies in place that reduce the up front investment in order to incentivize PV. This took place over the years in Australia, Belgium, Sweden, Japan, Italy and China. These subsidies are, by nature, part of the government expenditures and are limited by their capacity to free up 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.

## 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, the USA, to Belgium (until 2011), Switzerland, France, Japan, Netherlands and others. Italy uses a tax credit in the commercial segment. 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.

## RENEWABLE PORTFOLIO STANDARDS AND GREEN CERTIFICATES

The regulatory approach commonly referred to as "Renewable Portfolio Standard" (RPS) aims at promoting the development of renewable energy sources by imposing a quota of RE sources. 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. When available, 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, Romania and Korea, PV receives a specific number of these green certificates for each MWh produced. A multiplier can be 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 used the trading of green certificates 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 get the return on investment in 7 years. Romania uses a quota system, too, which however experienced a drop in the value of the green certificates in 2014. The UK still uses a system called ROC (Renewable Obligation Certificates) that are used for large-scale PV. It must be noted that Sweden and Norway share a joint, cross-border, Green Electricity Certificate system.

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. It is expected that these targets will be met by 2020. This overarching directive does not 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. In 2014 a new directive defined 2030 objectives but these so far have not been made compulsory.

## 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 this part of 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.

## SELF-CONSUMPTION SCHEMES

With around 60% of distributed PV installations, 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, Brazil). 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.

### Excess PV Electricity Exported to the Grid

Traditional self-consumption systems assume that the electricity produced by a PV system should be consumed immediately or within a 15 minutes timeframe in order to be compensated. The PV electricity not self-consumed is therefore injected into the grid.

Several ways to value this excess electricity exist today:

## MARKET DRIVERS IN 2014 / CONTINUED

- The lowest remuneration is 0: excess PV electricity is not paid while injected;
- Excess electricity gets the electricity market price, with or without a bonus (Germany);
- A FiT remunerates the excess electricity (Germany, Italy) at a pre-defined price. Depending on the country, this tariff can be lower or higher than the retail price of electricity.
- Price of retail electricity (net-metering), sometimes with additional incentives or additional taxes (Belgium, USA).

A 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 in The Netherlands in 2014. In Belgium, the system exists for PV installations below 10 kW. In Sweden, some utilities allow net-metering while in the USA, 44 states have implemented net-metering policies. In 2013, the debate started in the USA about the impact of net-metering policies on the financing of utilities, especially vertically integrated distribution actors. The conclusion so far was to either do nothing until the penetration of PV would reach a certain level (California) or to impose a small fee (Arizona) to be paid by the prosumer. Several emerging PV countries have proposed net-metering schemes or will do so in 2015 (Israel, Jordan, Dubai and Chile). Portugal is setting up a net-billing scheme.

### 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); moreover Scambio Sul Posto can be added to the the self-consumed energy, if any. In Israel, the net-billing system works on a similar basis.

### Grid Costs and Taxes

The opposition from utilities and in some cases 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 opposite direction. In Belgium, the attempt of adding a grid tax to maintain the level of financing of grid operators was stopped by the courts. While these taxes were cancelled later, they reveal a concern from grid operators in several countries. In Germany, the debate that started in 2013 about whether prosumers should pay an additional tax was finally concluded. The EEG surcharge will be paid anyway on self-consumed electricity. In Israel, the net-billing system is accompanied by grid-management fees in order to compensate the back-up costs and the balancing costs. 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 analysed 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 10 kW 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. 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 2014, an average 6 GW of PV (out of 38 GW installed) were traded on a regular basis on the electricity market.

Market premiums can use existing financial instruments: see the FiP paragraph above. In several countries, it starts to be recognized that the current organization of electricity markets will have to be revised in depth in order to allow variable renewables and especially PV to integrate them.

## SOFT COSTS

Financial support schemes have not always succeeded in starting the deployment of PV in a country. Several examples of well-designed FiT 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.

Soft costs remain high in several countries, despite gains reported in 2014. In the USA and Japan for instance, system prices for residential systems continue to be significantly higher than prices in key European markets. While the reason could be that installers adapt to the existing incentives, it seems to be more a combination of various reasons explaining why final system prices are not converging faster in some key markets

## 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 European level, 2014 saw the continuation of the revision of the grid codes.

In China, the adequacy of the grid remains one important question that pushed the government to favour more the development of decentralized PV in the future rather than large utility-scale power plants.

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

# TRENDS IN PV INCENTIVES

Once again in 2014, the most successful PV deployment policies based themselves on either FiT policies (most of the time without tendering process) or direct incentives (including tax breaks). The growth in Japan (FiT), China (FiT+direct incentives) and the USA (tax breaks, net-metering) shows how important these incentives remain. 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 in several countries. The emergence of schemes promoting the self-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 favour 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.

But the major outcome of 2014 consists in the widespread use of competitive calls for tenders in emerging PV markets that are driving prices very low in all parts of the world.

BIPV incentives have lost ground, with few countries maintaining adequate support schemes to favour their development (France and Switzerland) but a market for architectural BIPV is developing in Europe and to a lesser extent in Japan, Korea and the USA.

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

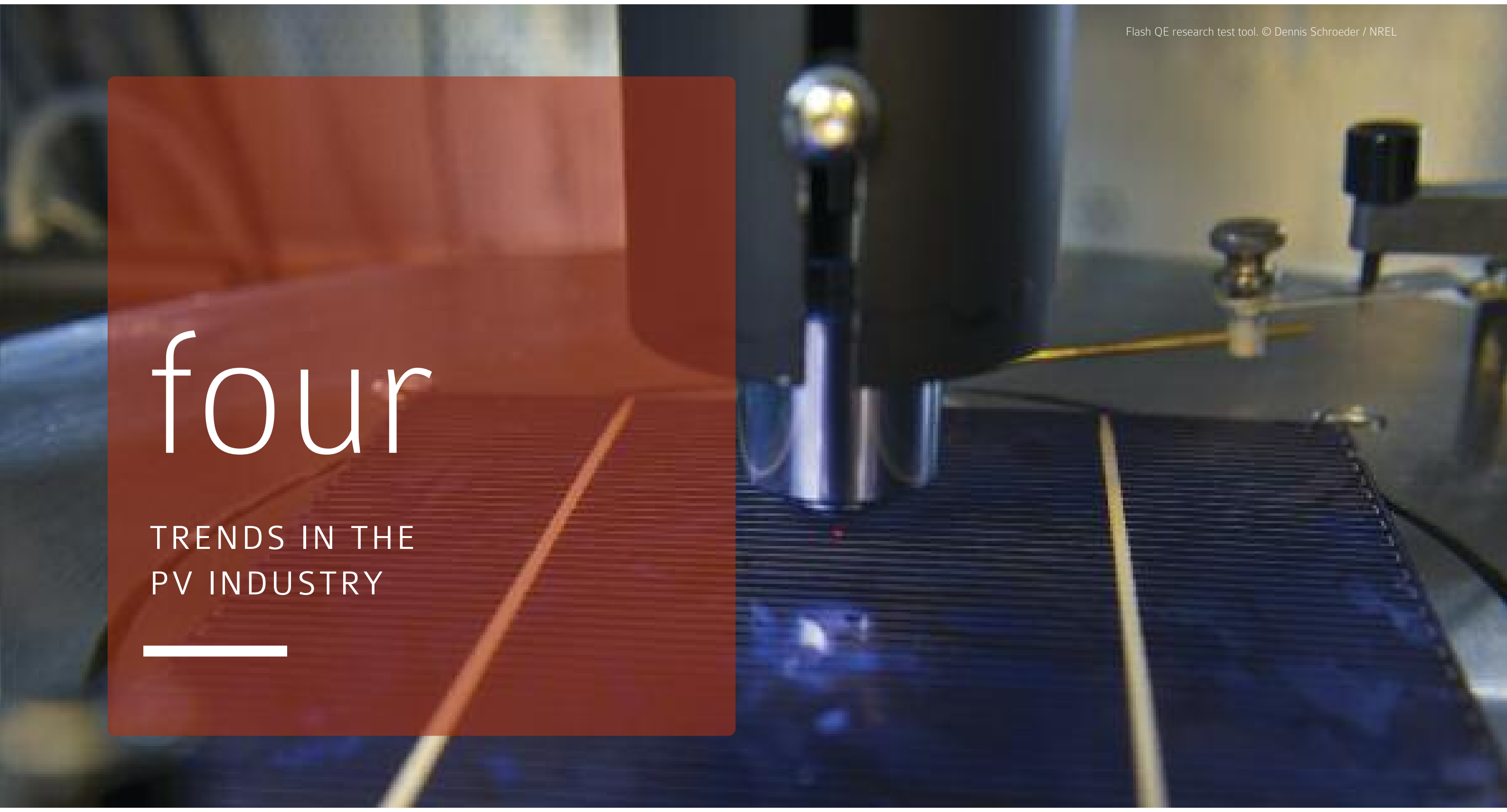
Finally, the arrival of local content policies in several countries that seemed to be an official answer to the local industry difficulties has not seen much additional development in 2014.

**TABLE 5:** OVERVIEW OF SUPPORT SCHEMES IN SELECTED IEA PVPS COUNTRIES[1]

| | AUS | AUT | BEL | CAN | CHN | DEN | FIN | FRA | GER | ISR | ITA | JPN | KOR | MEX | MYS | NLD | NOR | POR | SPA | SWE | SWI | THA | TUR | USA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LOWEST FEED-IN TARIFFS LEVELS (USD/kWh) | 0,05 | 0,13 | - | 0,25 | 0,10 | 0,07 | - | 0,09 | 0,38 | - | - | 0,30 | - | - | 0,30 | - | - | 0,09 | - | - | 0,15 | 0,17 | 0,14 | + |
| HIGHEST FEED-IN TARIFFS LEVELS (USD/kWh) | 0,54 | 0,17 | - | 0,35 | 0,16 | 0,11 | - | 0,36 | 0,41 | - | - | 0,34 | - | - | 0,31 | - | - | 0,19 | - | - | 0,27 | 0,21 | 0,14 | + |
| INDICATED HOUSEHOLD RETAIL ELECTRICITY PRICES (USD/kWh) | 0,27 | 0,27 | 0,27 | 0,06-0,15 | 0,09 | 0,40 | 0,21 | 0,19 | 0,38-0,41 | 0,15 | 0,21-0,27 | 0,28 | 0,12 | 0,11-0,14 | 0,10 | 0,23 | 0,11-0,16 | 0,30 | 0,25 | 0,27 | 0,17 | 0,07-0,1 | 0,17 | 0,09-0,37 |
| DIRECT CAPITAL SUBSIDIES | + | R | R | R | | | + | R | + | * | R | + | + | | | | | | + | + | | + | + | + |
| GREEN ELECTRICITY SCHEMES | + | + | R | + | | | | | U | * | | | | | | + | | | | + | U | | | U |
| PV-SPECIFIC GREEN ELECTRICITY SCHEMES | + | + | R | | | | | | | | | | | | | | | | | | + | | | + |
| RENEWABLE PORTFOLIO STANDARDS | + | | | | | | | | | | | + | + | | | | + | | | + | | | | + |
| PV SPECIAL TREATMENT IN RPS | | | | | | | | | | | | | + | | | | | | | | | | | + |
| FINANCING SCHEMES FOR PV / INVESTMENT FUND | + | + | R | | | | | | + | | + | + | | | | + | | + | | | | | | + |
| TAX CREDITS | | | + | | | | | - | | | + | +/* | | | + | + | | | + | | + | | | + |
| NET-METERING / NET-BILLING / SELF-CONSUMPTION INCENTIVES | R | + | R | + | + | + | | R | | + | + | + | | + | | + | | + | | U | * | | + | |
| COMMERCIAL BANK ACTIVITIES | + | | | | | | | + | + | | + | +/* | | | + | | | | | | + | + | | + |
| ELECTRICITY UTILITY ACTIVITIES | + | | | + | | | | | + | | + | + | + | | + | | | | | + | + | | | + |
| SUSTAINABLE BUILDING REQUIREMENTS | + | + | | + | + | + | | | + | | + | + | + | | + | | | | | | + | | | U |

NOTES:
**1** NUMBERS ARE ROUNDED VALUES IN USD ACCORDING TO AVERAGE EXCHANGE RATES.
**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 2015.
**+** THIS SUPPORT SCHEMES HAS BEEN USED IN 2014.
**-** THIS SUPPORT SCHEMES HAS BEEN CANCELED IN 2014.

SOURCE IEA PVPS.



Flash QE research test tool. © Dennis Schroeder / NREL

# four

## 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 2014. Reference is made 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/module manufacturing in the IEA PVPS countries during 2014 is presented in Annex 3 and is directly based on the information provided in the National Survey Reports of IEA PVPS member countries.

In 2014, the PV industry saw clear signs of further growth of the global PV market and major PV module manufacturers started to announce capacity enhancement. Trade conflicts affected the selection of production sites and plans for manufacturing in emerging market countries were also reported.

Meanwhile, the market prices of silicon feedstock, PV cells and modules stabilized in 2014. The prices continued to decline until 2012 and increased slightly in 2013. In 2014, the prices continued to level off and moderately decreased throughout the year. Some manufacturers have shifted focus to downstream business, such as PV project development. Lower profit margins also contributed to the ongoing consolidation of manufacturers, as well as PV system installers and developers.

### FEEDSTOCK, INGOTS AND WAFERS (UPSTREAM PRODUCTS)

Wafer-based crystalline silicon technology remains the dominant technology for making PV cells. Although some IEA PVPS countries reported on production of feedstock, ingots and wafers, the picture from the National Survey Reports of these PV industry supply chain segments are not complete. Many countries outside the IEA PVPS network contribute significantly to PV components production. Consequently, this section provides more complete background information on the upstream part of the global PV value chain.

As of the end of 2014, global manufacturing polysilicon capacity was around 380 000 tonnes. The so-called Tier 1 producers represented more than 70% of the production and polysilicon manufacturers still face excess supply issues. In 2014, the polysilicon spot price from January to November ranged between 20 and 22 USD/kg but in December, it dropped to 19 USD/kg due to the announcement of new antidumping tariffs in the USA.

In 2014, it has been estimated that about 260 000 tonnes of polysilicon were produced and that the top 5 producers, namely GCL-Poly Energy (China), Wacker Chemie (Germany), OCI (Korea), Hemlock Semiconductor (USA) and REC Silicon (USA) accounted for more than 60% of the global polysilicon supply. Considering that 5,7 g of polysilicon are used for 1 W of solar cells, its production capacity remains higher than 1,5 times the actual global demand for crystalline silicon PV cells. Despite the gap between the capacity and demand, new plans for manufacturing polysilicon have continued to be reported and about

65 000 tonnes/year of new capacity was added in 2014. In 2015, planned global manufacturing capacity will reach about 430 000 tonnes.

Most of major manufacturers have adopted conventional technologies such as the Siemens and FBR (Fluidized bed reactor) processes, which are also used to supply polysilicon for the semiconductor industry. The FBR process requires less electricity than the Siemens process and produces granular polysilicon that can be efficiently packed in the crucibles with polysilicon blocks. To gain some cost advantage, some of the major companies are planning to enhance their capacity with the FBR process in 2015.

As in the previous year, major polysilicon producers from IEA PVPS countries in 2014 were China, Germany, Korea, USA, Japan and Malaysia. China continued to be the largest producer and consumer of polysilicon in the world. China reported that it produced 136 000 tonnes of polysilicon, a 61% increase over 84 600 tonnes in 2013, accounting for around 50% of total global production. This can be partially explained by the anti-dumping duties (ADs) imposed on imported polysilicon and scheduled changes for AD exemption rule for imported polysilicon to process for export. In addition, China imported 96 000 tonnes of polysilicon from mainly Germany, Korea, USA and Malaysia. GCL-Poly Energy (Jiangsu Zhongneng Polysilicon Technology Development), the largest producer in China and the world, produced 66 876 tonnes in 2014. The company completed a new plant with the FBR process (7 000 tonnes/year) in 2014 and plans to start operation in 2015. The second largest producer, TBEA Solar manufactured 17 500 tonnes. The other major manufacturers in China are China Silicon, Daqo New Energy, and ReneSola Silicon Material. Small scale polysilicon producers in China were continuously closed down in 2014 and the production volume from the top 10 companies accounted for 92% in total.

Germany reported that it had 53 980 tonnes/year of polysilicon manufacturing capacity in 2014. Wacker Chemie produced around 50 000 tonnes in 2014. Wacker Chemie is constructing a new plant with 20 000 tonnes/year of capacity in Tennessee, USA, scheduled to start operating in October 2015. South Korea has 70 000 tonnes/year of manufacturing capacity. The largest Korean producer OCI has 42 000 tonnes/year capacity. In 2014, Hanwha Chemical entered into polysilicon manufacturing and started commercial operation of its plant with 6 000 tonnes/year of capacity in 2014. Samsung Fine Chemicals – SunEdison (SMP) also started pilot operation of 3 000 tonnes/year of polysilicon plant using the FBR process in 2014. The USA had over 70 000 tonnes/year of production capacity with three major manufacturers (Hemlock Semiconductor Corporation, REC Silicon and SunEdison). The USA reported 49 059 tonnes of polysilicon production, about 23% of production increase compared to 2013 (39 988 tonnes). Tokuyama produced 7 800 tonnes in Japan in 2014 and started its operation in Malaysia in same year. The company has total of 20 000 tonnes of production capacity in Japan (6 200 tonnes/year) and Malaysia (13 800 tonnes/year).

Canada, the USA and Norway reported activities of polysilicon producers working on metallurgical process aiming at lowering production cost. Silicor Materials in the USA have a plant in Canada and announced a plan to build a commercial manufacturing facility in Iceland. Elkem Solar in Norway had 6 000 tonnes of manufacturing capacity.

To produce single-crystalline silicon (sc-Si) ingots or multicrystalline silicon (mc-Si) ingots, the basic input material consists of highly purified polysilicon. The ingots need to be cut into bricks or blocks and then sawn into thin wafers. 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 mc-Si ingots are only used in the PV industry. Ingot producers are in many cases producers of wafers as well. Major PV module manufacturers such as Yingli Green Energy (China), ReneSola (China), Trina Solar (China), SolarWorld (Germany), Panasonic (Japan), Kyocera (Japan) and many others also manufacture silicon ingots and wafers for their in-house uses. This situation makes it difficult to track down the entire picture of ingot and wafer production. However due to cost pressures, some of the major PV module producers that established vertically integrated manufacturing frameworks are now buying wafers from specialized manufacturers because of cost and quality advantages, despite their own production. In 2014, it is estimated that over 45 GW of crystalline silicon wafer were produced. Due to high industry concentration, China and Taiwan had more than 80% share of the global production.

As in 2013, China was still in 2014 the largest producer of wafers for solar cells in the world. China increased its production capacity of wafers from 40 GW/year to 50,4 GW/year in 2014 and reported that it produced 38 GW, a 29% increase compared to 2013. According to the National Survey Report of China, Chinese companies accounting for 76% of total production in the world. GCL-Poly Energy is the largest producer in China (and the world) and it produced 13 GW in 2014. Compared to China, manufacturing capacity in other IEA PVPS countries remained small: Korea (2,5 GW/year), Germany (1,8 GW/year), Japan (more than 1,2 GW/year). Malaysia, Norway and the USA also reported wafer manufacturing activities. In Non IEA PVPS countries, Taiwan is a major country for solar wafers production with about 10 GW/year of production capacity with 13 companies including solar cell manufacturers. In Singapore, the Norwegian company REC Solar produces solar wafers for its own use with about 1 GW/year capacity.

The mc-Si wafer spot price in 2014 ranged between 0,84 and 1,15 USD/wafer up from 2013 price which ranged between 0,81 and 0,85 USD/wafer. This shows a slight increase but prices still remain rather low. The price of high quality mc-wafers are around 5% higher because wafer qualities contribute to increase the conversion efficiency of solar cells. sc-Si wafer were traded in 2014 within the price range of 1,15 to 1,35 USD/wafer.

Larger sized crucibles for mc-Si wafers (G6 generation crucible for 800 to 850 kg charging) and slicing with diamond wire saws (DW) for sc-Si wafers are driving wafer prices down. Several start-up companies in the USA and Europe are developing new processes to manufacture wafers without conventional wire-sawing.

# PV CELL & MODULE PRODUCTION

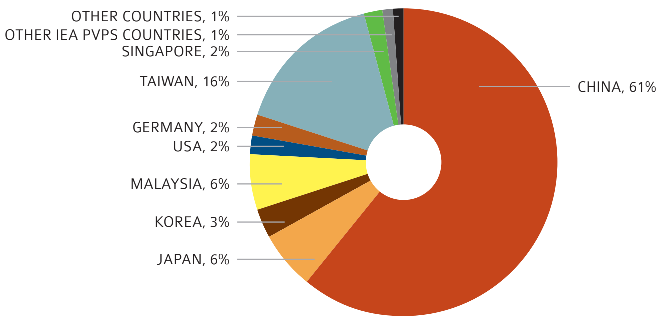
Global PV cells (crystalline silicon PV cells and thin-film PV cells) production in 2014 is estimated to be around 46,7 GW (estimation based on reported figures and other sources and excludes at least partially the so-called "double counting"). Just like last year, China reported the largest production of PV cells with about 28 GW in 2014, a 27% increase compared to 2013.

As shown in Figure 12, China now covers more than half of the global share of PV cells production. Yingli Green Energy and JA Solar produced 3,1 GW of solar cells in 2014 followed by Trina Solar (2,7 GW) and Jinko Solar (1,9 GW). Besides China, other major IEA PVPS countries producing PV cells are Japan, Malaysia, Germany, the USA, and Korea. In 2014, the IEA PVPS countries accounted for around 80% of the global solar cells production. The major Non IEA PVPS countries manufacturing solar cells are Taiwan, the Philippines, Singapore and India. Taiwan has more than 10 GW/year of production capacity, the second largest capacity following China. Figure 14 shows the evolution of PV cells production volume in selected countries.

The picture for PV module production is similar to that of the previous year. Global PV module production (crystalline silicon PV and thin-film PV) is estimated at 46 GW (estimation based on reported figures ant other sources considering the so-called "double counting"). More than 95% of PV modules were produced in IEA PVPS member countries.

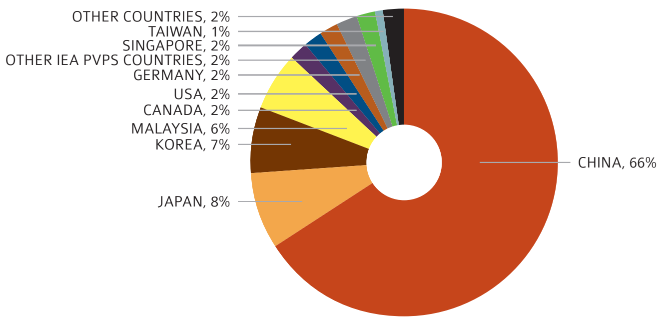
The largest producer was China that accounted for 66% of global PV module production as shown in Figure 13. China reported 30,4 GW of PV module production. The largest producer in China (and globally) in 2014 was Trina Solar that produced 3,6 GW of PV modules. Trina Solar plans to increase its production capacity of

**FIGURE 12:** SHARE OF PV CELLS PRODUCTION IN 2014



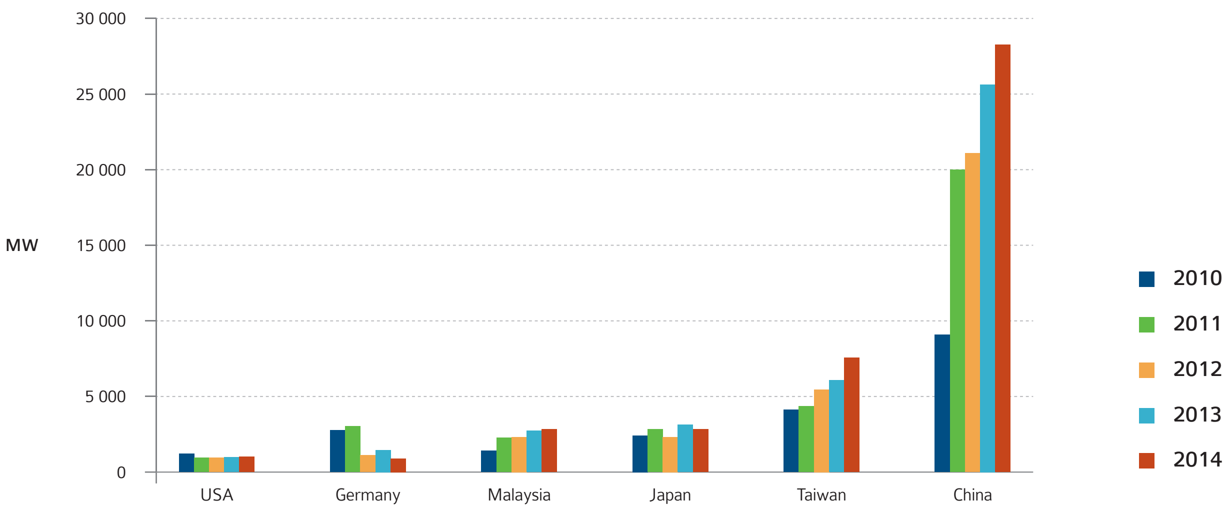

**SOURCE** IEA PVPS, RTS CORPORATION.

**FIGURE 13:** SHARE OF PV MODULE PRODUCTION IN 2014




**SOURCE** IEA PVPS, RTS CORPORATION.

**FIGURE 14:** EVOLUTION OF THE PV INDUSTRY IN SELECTED COUNTRIES - PV CELL PRODUCTION (MW)




**SOURCE** IEA PVPS, RTS CORPORATION.

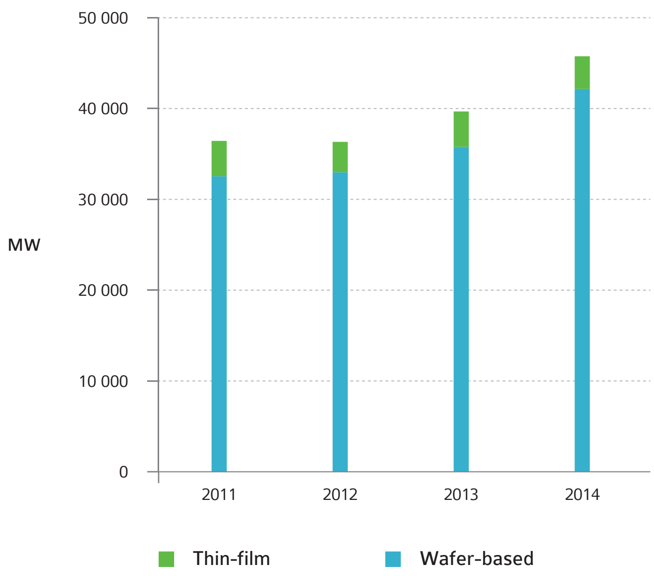
PV modules to 5 GW/year in 2015. It is noted that Trina Solar produced 2,7GW of solar cells for its in-house use and procured almost 0,9 GW of solar cells from other companies. Yingli Green Energy that produced 3,4 GW of PV modules ranked No.2 in China and globally. It was reported that major Chinese companies will increase their production capacities overseas such as in Malaysia, Thailand, India and in other emerging markets in order to avoid existing ADs resulting from trade conflicts. As a result, PV module production bases will be more and more diversified in the near term.

Other IEA PVPS countries producing PV modules in 2014 were Japan, Malaysia, Germany, Korea and the USA. Australia, Austria, Canada, Denmark, France, Italy, Sweden, Thailand and Turkey also have PV module production capacities. Driven by the strong demand, Japan produced 3,8 GW of PV modules mainly for domestic use. Korea and Malaysia produced close to 3 GW (2,9 GW and 2,8 GW respectively). In Europe, Germany was the largest PV module producer with 3,8 GW of production capacity. The USA manufactured about 1 GW of PV modules. Some US companies reported capacities enhancement plans inside the USA. One of the announcements that attracted attention was that Silevo, a subsidiary of SolarCity, started the construction of GW-scale manufacturing plant for crystalline silicon PV modules in the state of New York.

Non IEA PVPS member major producing countries are Singapore, Taiwan and India. In addition to these countries, the production bases were established or planned in various countries. In 2014, Qatar Solar Energy opened a vertically integrated production line of PV cell/modules in Qatar. Other new plans for manufacturing or capacity enhancement were reported in Saudi Arabia, Egypt, Brazil, South Africa, etc. In Europe, Poland is developing as a production base, mainly through outsourcing companies producing for large players.

Thin-film PV modules are mainly produced in Malaysia, Japan, the USA, Germany, Italy and China. The largest thin-film producer remained First Solar that produced about 1,85 GW of CdTe PV modules in its factories in the USA and Malaysia in 2014. It ranked sixth in the global PV modules production ranking. The second largest thin-film PV manufacturer in 2014 was Solar Frontier. It produced 952 MW of CIS modules in Japan. Other thin-film manufacturers were reported from Germany, Italy, China and Thailand in addition to the USA and Japan already mentioned. Their production volumes remained relatively small compared to the two leaders. It is estimated that 3,6 GW of thin-film PV modules were produced in 2014, accounting for 8% of total PV module production, all technologies included (see Figure 15). The production volume of thin-film silicon (aSi and µSi technologies) has been decreasing due to lower efficiency and cost competitiveness. Several thin-film silicon manufacturers announced business withdrawals in 2014 and little progress is expected in the coming years. As well as in previous years, efforts on R&D and commercialization of CIGS PV modules are continuously reported in a number of IEA PVPS member countries. They are aiming at higher conversion efficiencies and higher throughput. Thin-film PV modules using flexible or light-weight substrates are also the focus of R&D efforts for BIPV applications.

**FIGURE 15:** PV MODULE PRODUCTION PER TECHNOLOGY IN IEA PVPS COUNTRIES 2011-2014 (MW)



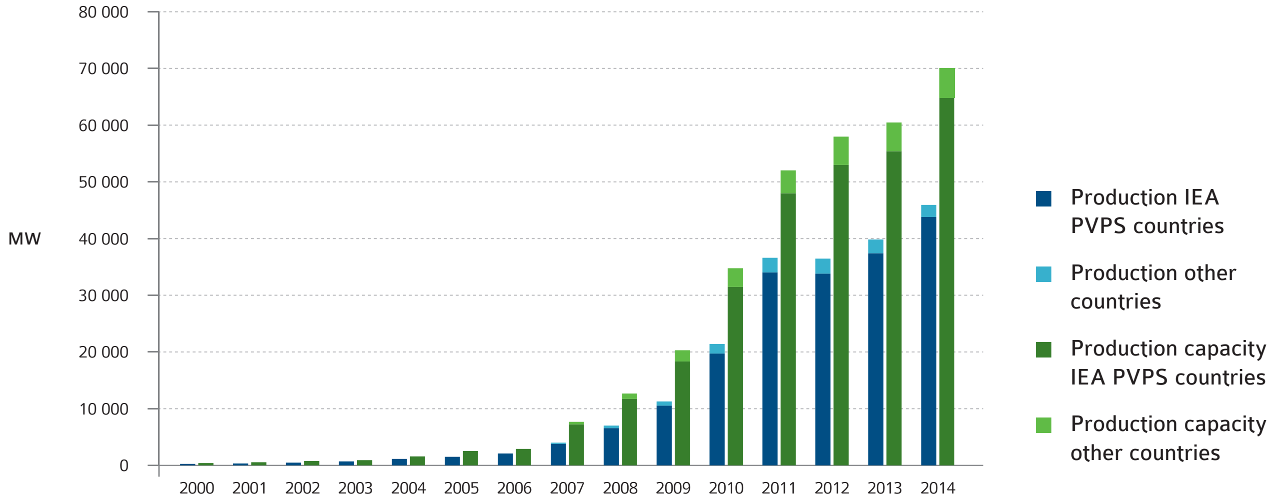

SOURCE IEA PVPS, RTS CORPORATION.

In 2014, activities on concentrator PV (CPV) cells and modules have been reported from several IEA PVPS member countries. This technique is mainly based on specific PV cells using group III-V materials, such as GaAs, InP, etc. Germany, Australia, the USA, France, Spain and again China were active in this area. While conversion efficiencies of CPV solar cells has been improving, CPV systems seem to require more cost competitiveness progresses in order to compete with conventional PV systems and a consolidation in the sector could be expected.

In 2014, the PV module manufacturers continued to face excess production capacities. It is difficult to estimate the actual global PV modules manufacturing capacity that are really active. China reported its manufacturing capacity reached 63 GW/year in 2014. However, considering all the capacity was not actually used, it is estimated that the global production capacity of PV modules in active was about 65 GW/year in 2014. Figure 16 shows the trends of estimated global production capacity and production volume of PV modules. While the utilization rate of manufacturing capacities in 2014 improved to 65% from 62% in 2013, the PV module spot price continued to drop and reached the 0,6 USD/W level at the end of 2014 from the range of 0,7 to 0,73 USD/W in 2013. Reflecting this same situation, the consolidation of the manufacturers continued to be observed in 2014 in the same way as in 2013. The South Korean Hanwha Group merged its two subsidiary module manufacturing companies, Hanwha Solar One in China and Hanwha Q-cells in Germany established a joint 3,28 GW of manufacturing capacity. In Taiwan, Motech Industries, a major solar cell manufacturer announced its merge with Topcell. Some companies also enhanced their manufacturing capacities with the acquisition of closed factories or establishing joint ventures with other companies.

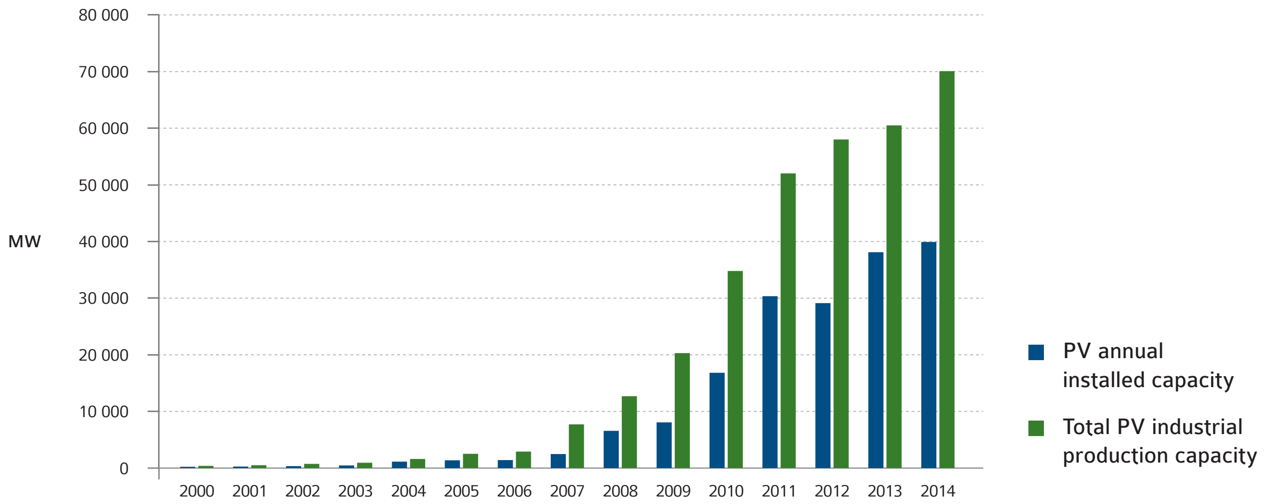
## PV CELL & MODULE PRODUCTION / CONTINUED

**FIGURE 16:** YEARLY PV PRODUCTION AND PRODUCTION CAPACITY IN IEA PVPS AND OTHER MAIN MANUFACTURING COUNTRIES 2000-2014 (MW)




SOURCE IEA PVPS, RTS CORPORATION.

**FIGURE 17:** PV INSTALLATIONS AND PRODUCTION CAPACITIES 2000-2014 (MW)




SOURCE IEA PVPS, RTS CORPORATION.

**TABLE 6:** EVOLUTION OF ACTUAL MODULE PRODUCTION AND PRODUCTION CAPACITIES (MW)

| | ACTUAL PRODUCTION | | | PRODUCTION CAPACITIES | | | |
|---|---|---|---|---|---|---|---|
| YEAR | IEA PVPS COUNTRIES | OTHER COUNTRIES | TOTAL | IEA PVPS COUNTRIES | OTHER COUNTRIES | TOTAL | UTILIZATION RATE |
| 1993 | 52 | | 52 | 80 | | 80 | 65% |
| 1994 | | | | | | | |
| 1995 | 56 | | 56 | 100 | | 100 | 56% |
| 1996 | | | | | | | |
| 1997 | 100 | | 100 | 200 | | 200 | 50% |
| 1998 | 126 | | 126 | 250 | | 250 | 50% |
| 1999 | 169 | | 169 | 350 | | 350 | 48% |
| 2000 | 238 | | 238 | 400 | | 400 | 60% |
| 2001 | 319 | | 319 | 525 | | 525 | 61% |
| 2002 | 482 | | 482 | 750 | | 750 | 64% |
| 2003 | 667 | | 667 | 950 | | 950 | 70% |
| 2004 | 1 160 | | 1 160 | 1 600 | | 1 600 | 73% |
| 2005 | 1 532 | | 1 532 | 2 500 | | 2 500 | 61% |
| 2006 | 2 068 | | 2 068 | 2 900 | | 2 900 | 71% |
| 2007 | 3 778 | 200 | 3 978 | 7 200 | 500 | 7 700 | 49% |
| 2008 | 6 600 | 450 | 7 050 | 11 700 | 1 000 | 12 700 | 52% |
| 2009 | 10 511 | 750 | 11 261 | 18 300 | 2 000 | 20 300 | 52% |
| 2010 | 19 700 | 1 700 | 21 400 | 31 500 | 3 300 | 34 800 | 57% |
| 2011 | 34 000 | 2 600 | 36 600 | 48 000 | 4 000 | 52 000 | 65% |
| 2012 | 33 787 | 2 700 | 36 487 | 53 000 | 5 000 | 58 000 | 58% |
| 2013 | 37 399 | 2 470 | 39 869 | 55 394 | 5 100 | 60 494 | 62% |
| 2014 | 43 799 | 2 166 | 45 965 | 64 814 | 5 266 | 70 080 | 63% |

**NOTE:** CHINESE PRODUCTION AND PRODUCTION CAPACITY ARE INCLUDED SINCE 2006 EVEN THOUGH CHINA PARTICIPATES IN PVPS SINCE 2010.

**SOURCE** IEA PVPS, RTS CORPORATION.

## TRADE CONFLICTS

The trade conflicts that emerged about PV products, including polysilicon and glass for PV modules, continued to have an impact on PV companies in 2014. To avoid the conflicts, PV module manufacturers announced new production enhancement plans in Malaysia, Thailand, India and other countries not affected by the trade dispute. For example, REC Silicon, the Norwegian company with a manufacturing base in USA announced it establishes a joint venture with Chinese companies in order to build a FBR process plant in China.

In 2014, the initiation of investigations regarding the dumping of Chinese PV products were reported in Australia and Canada. In Australia, investigations started in May 2014 and only one year later, in April 2015, the Antidumping Committee confirmed the dumping. However it did not impose duties since no damages were reported on the (small) Australian PV manufacturing sector. In Canada, the Canada Border Services Agency (CBSA) started the investigation of dumping and unfair subsidies of China-made PV products in December 2014 and decided to impose anti-dumping duties (AD) and countervailing duties (CVD) in July 2015.

In the USA, the Department of Commerce (DOC) decided to impose AD and CVD for PV producers using PV cells made in China in December 2012. A new AD investigation for PV cell and modules made in China and Taiwan was filed to the DOC in December 2013 in order to close the loopholes. In January 2015, the DOC decided to impose AD and CVD for Chinese PV products and AD for Taiwanese products.

The European Union (EU) also started an investigation on dumping and unfair subsidies from Chinese PV manufacturers in September 2012 and the European Commission (EC) decided to impose provisional AD duties in June 2013. However, EC and the Chinese PV industry reached an agreement on minimum prices and maximum shipping volume. Because of violation of this agreement and bypassed export through 3rd parties, the EC delisted some companies from this agreement in June 2015, imposing them high AD duties.

In China, the Ministry of Commerce (MoC) started an 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 July 2012. The MoC announced

## TRADE CONFLICTS / CONTINUED

provisional AD to USA and Korean made polysilicon in July 2013 and CVD to polysilicon imported from USA in September 2013. Then MoC announced final results in January 2014 and set AD for USA manufacturers from 53,3% to 57% and AD for Korean manufacturers from 2,4% to 48,7%. The MoC also started an antidumping survey for polysilicon imported from Europe in November 2012. However, MoC concluded not to impose AD to products of Wacker Chemie, a German producer. While the impact of AD was limited because Chinese importers took advantage of processing rules that allows exemption of import duties for imported materials processed in China for export, Wacker and OCI with lower AD increased their share among the imported polysilicon in China. However, in September 2014, China decided to suspend this rule for imported polysilicon in order to close any possible loopholes.

## BALANCE OF SYSTEM COMPONENT MANUFACTURERS AND SUPPLIERS

Balance of system (BOS) component manufacturers and suppliers are important parts of the PV value chain. They are accounting for an increasing portion of system costs as PV module prices felt dramatically in the last years. Accordingly, the production of BOS products has become an important sector in the PV industry.

Inverter technology is currently the main focus of interest because the demand for grid-connected PV systems has continued to increase and now represents the wide majority of PV installations globally. In several countries, new grid codes require the active contribution of PV inverters to grid management and grid protection: 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.

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. Larger centralized inverters have been developed with rated capacities over 2 MW (a 4,5 MW product has been made available). For large-scale projects, the adoption of string inverters has been observed. The economic competitiveness of centralized and string inverters for large-scale projects is subject to debate.

PV inverters were produced in many IEA PVPS member countries in 2014: China, Japan, Korea, Australia, the USA, Canada, Germany, Spain, Austria, Switzerland, Denmark, France and Italy. Unlike PV modules, the supply chains of PV inverters are impacted by national codes and regulations and national origin in such a way that domestic manufacturers tend to dominate domestic PV markets. However, in some markets where the cost pressure is strong, lower price products started to increase their share.

China reported in 2014 that the inverter manufacturers delivered more than 16 GW in the country and abroad. US companies shipped approximately 4,2 $GW_{AC}$ of PV inverters in 2014, approximately 93% of all USA systems installed during that time period. In Japan, the market was still dominated by domestic inverter manufacturers in 2014 (which represented more than 15 companies) but the number of foreign companies that entered into the Japanese market increased gradually.

The micro-inverters (inverters attached to one single PV module) market is expanding. The USA accounted for more than 70% of global micro-inverter shipments. Those were mainly used for residential applications.

As well as PV module suppliers, inverter manufacturers were also suffering from rapid price reduction and tighter competition. This led to a series of announcements of withdrawal or insolvency in 2014. As it can be understood, the consolidation phase started in 2013 for the inverter manufacturers and continued into 2014.

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. With the development of the self-consumption business models, attention for storage batteries has been growing. In some regional markets, such as Hawaii and Australia, where PV already achieved a rather high penetration, the demand for storage batteries for PV systems is increasing. However, storage batteries are still expensive and in most cases not subsidised with the exception of Germany and Japan. In fact, in Germany, PV systems below 30 kW can benefit from a storage batteries subsidy while in Japan, through the national subsidy for residential storage batteries, more and more residential PV systems are sold with storage batteries.

With the market growth experienced in the last years, operation and maintenance (O&M) of PV system became more and more important and O&M businesses are emerging as an important sector in the PV industry.

## CONCLUSION

In 2014, the global PV installed capacity reached around 40 GW while the PV modules production reached 46 GW. Given the installation trend in the first quarter of 2015, the PV installed capacity is expected to grow in 2015. Hoping for a continued market growth, production capacity enhancements started in 2014 but oversupply issues along the value chain have not been addressed sufficiently. PV manufacturers are now seeking new ways to make profit by achieving economy of scale through new investments, mergers, partnerships or shifting to the downstream business.

Consolidations were announced by suppliers of PV cells, modules or BOS, as well as in the downstream sector. In order to avoid the impact of trade conflicts, the production started to relocate and with the growth of PV market in emerging countries, PV modules production is now planned in various regions, making the PV manufacturing really global.

## R&D ACTIVITIES AND FUNDING

The public budgets for research and development (R&D) in 2014 in the IEA PVPS countries are outlined in Table 7.

Expenditures for the PV R&D of IEA PVPS member countries show great differences in scale. While some countries show a growth in the budget, others reported decrease of the public funding for R&D in 2014 in comparison to 2013. The USA reported more than 100% increase in 2014 and also Japan, France, Austria and Korea experienced an increase of budget compared to 2013. Australia reported an 80% decrease in 2014.

As in 2013, it is interesting to note that more governments are clearly identifying the benefits of this technology's further development, the need for a smooth integration with existing energy systems and the benefits of innovations. Another point is that the scale of the budget does not reflect the production volumes of PV modules. The most significant reporting countries in terms of R&D budget are the USA, Korea, Japan, and Germany among IEA PVPS countries. China also conducts a variety of national research activities but its total budget regarding PV has not been officially disclosed.

However, it should be noted that analyzing or comparing public budgets for R&D is not simple, due to several reasons. The definition of R&D and demonstration program varies among countries and the annual budget allocation does not show the entire scale of multi-year R&D programs (the first year's budget tends often to be larger). European Union (EU) member countries can access to funding from European programs in addition to national programs to conduct PV R&D projects. In addition, it is getting more and more difficult to identify the part related to PV technology research that is conducted under the more general renewable energy research programs on grid integration or applications for energy storage systems.

A brief overview of the R&D sector in IEA PVPS member countries and organizations is presented below (the ranking of the countries follows the size of the budget in USD in 2014).

For a better understanding of each member country's activities, the reader will refer to the National Survey Reports (NSRs) on the IEA PVPS website. NSRs present a comprehensive summary of the R&D activities in each country as well as more detailed information on R&D activities and public budgets.

**TABLE 7:** R&D FUNDING IN 2014

| COUNTRY | R&D IN MUSD | INCREASE/DECREASE FROM 2013 |
|---|---|---|
| AUSTRALIA | 21,7 | ↓ |
| AUSTRIA | 25,7 | ↑ |
| CANADA | 10,8 | ↓ |
| CHINA | NA | |
| DENMARK | 5,3 | ↑ |
| FRANCE | 9,3 | ↑ |
| GERMANY | 54,7 | ↓ |
| ITALY | 8,0 | ↑ |
| JAPAN | 97,2 | ↑ |
| MALAYSIA | NA | |
| KOREA | 202,4 | ↑ |
| NORWAY | 12,1 | ↓ |
| SPAIN | 23,9 | |
| SWEDEN | 13,6 | ↑ |
| SWITZERLAND | NA | |
| THAILAND | NA | |
| USA | 439,0 | ↑ |

SOURCE IEA PVPS.

The USA has been a clear leader in terms of R&D public funding for PV (439 MUSD, the largest in IEA PVPS member countries in 2014). Its Department of Energy (DoE) conducts the research, development, and deployment (RD&D) of all solar energy technologies through its Solar Energy Technologies Program (SETP). In February 2011, the SunShot Initiative was launched, a program focusing on driving innovation to make solar energy systems cost-competitive with other forms of energy. To reach this goal, the DoE is supporting efforts by private companies, academia, and national laboratories to drive down the cost of utility-scale solar electricity to about 0,06 USD/kWh (a level currently reached in some countries), and distributed solar electricity to be at, or below, retail rates. This, in turn, could enable solar-generated power to account for 14% of The Americas electricity generation by 2030 (assuming other systemic issues are addressed as well). By funding selective RD&D concepts, the SunShot Initiative promotes a genuine transformation in the ways the USA generate, store, and utilize solar energy. The initiative focuses on removing the critical barriers for the system as a whole, including technical and non-technical barriers to installing and integrating solar energy into the electricity grid. In addition to

## R&D ACTIVITIES AND FUNDING / CONTINUED

investing in improvements in solar technologies and manufacturing, the department focuses on integrating solar generated energy systems into the electricity grid and reducing installation and permitting costs. The DoE focuses on innovative technology and manufacturing process concepts applied to PV.

Korea has not officially reported public spending related to the year 2014 but it allocated 202,4 MUSD for 2013; this figure was the second highest after USA. Since 2008, the Korean government has promoted the NRE development extensively under the slogan of "Green and Strong Nation," and government-led R&D programs have been consistently initiated. The annual average growth of PV R&D budget for the period 2009 - 2013 was 8,7%, similar to other sectors of national R&D. The scope of PV R&D then expanded to a broader spectrum, reducing the Si solar cell related R&D, while increasing the thin-film related R&D. The objectives of PV R&D also shifted from being only solar cell focused R&D to a wider spectrum, including R&Ds for PV systems, PV electricity generation and various PV applications in order to facilitate the PV dissemination. It is reported that breakthrough and core technologies essential to various types of solar cells were developed, and Korean-made polysilicon manufacturing technology was acquired.

In Japan, the Ministry of Economy, Trade and Industry spent 97,2 MUSD in 2014 for PV R&D. New Energy and Industrial Technology Development Organization (NEDO) conducted "R&D for High Performance PV Generation System for the Future" and "R&D on Innovative Solar Cells" in FY 2014. Under "R&D for High Performance PV Generation System for the Future", projects were conducted for the areas of crystalline silicon solar cells, thin-film silicon solar cells, CIS and other polycrystalline compound semiconductor solar cells, dye sensitized solar cells (DSCs) and organic solar cells (OPV) aiming at establishing technologies to reduce PV module cost. Under "R&D on Innovative Solar Cells," four projects continued; 1) post-silicon solar cells for ultra-high efficiencies; 2) thin-film multi-junction novel solar cells with a highly-ordered structure; and 3) thin-film full spectrum solar cells with low concentration ratios and 4) high-efficiency concentrating solar cells, a joint research of European Union (EU) and Japan as an exploratory research aiming at a cell conversion efficiency of 40%. In 2014, NEDO published a new guidance for technology development called the "NEDO PV Challenge".

In Germany, R&D is conducted under the 6th Programme on Energy Research, "Research for an Environmental Friendly, Reliable and Economical Feasible Energy Supply", which came into force in August 2011. Within this framework, the Federal Ministry for Economic Affairs and Energy (BMWi) as well as the BMBF (Federal Ministry of Education and Research) support R&D on different aspects of PV. BMWi focused of six focal points: silicon wafer technology, thin-film technologies, especially based on chalcopyrites, quality control and lifetimes, system technology for decentralised grid-connection and island systems, Concentrated Solar Power and other alternative concepts as well as cross-cutting issues such as Building Integrated PV (BIPV), recycling or research on the ecological impact of PV systems.

Austria reported activities of the Federal Ministry of Transport, Innovation and Technology (BMVIT) and the Austrian Climate and Energy Fund (KLIEN). These organizations managed most of the projects conducted with national projects. The national RTD is focusing on materials research, grid integration as well as building integration.

Australia allocated 21,7 MUSD in 2014 for R&D activities. Current activities are led by the Australian Renewable Energy Agency (ARENA) and the Australian Research Council (ARC). Research is carried out largely in Australian universities and institutes, plus a small number of private companies that carry out research into product development and design, as well as research and analysis of the role of PV in the energy market. In 2014, ARENA provided 21,5 MAUD to 12 solar research and development projects and ARC provided 2,6 MAUD for PV related R&D.

Spain's R&D public budget for 2014 was 23,9 MUSD. About 10 research groups are now working on crystalline silicon. In 63 work areas, 155 institutions are engaged in PV R&D and more than 700 people are working in this field. Highlighted topics in 2014 were: development of silicon, to a solar standard, purified via metal, reaching standards similar to those of silicon purified by conventional ways and 40% reduction in radiation losses in the Siemens reactor through the use of heat shields.

Sweden allocated 13,6 MUSD for R&D in 2014. Its solar cell related research consists largely of fundamental research in new types of solar cells such as CIGS technology and photovoltaic materials. Before 2013, no research on the world-dominant silicon technology has been conducted, but now Karlstad University has initiated activities within this topic. Furthermore, there are some smaller groups that focus on PV systems and PV in the energy system oriented research.

Norway spent about 12,1 MUSD in 2014. Most of the R&D projects are focused on the silicon chain from feedstock to solar cells research, but also related to fundamental material research and production processes. A growing supply business is also filling out the portfolio of projects. The Norwegian Research Centre for Solar Cell Technology has completed its fifth year of operation and leading national research groups and industrial partners in PV technology are now participating.

Total public budget in Canada for R&D was 10,8 MUSD. Several organizations are involved in R&D activities. Sustainable Development Technology Canada (SDTC) supports the development and demonstration of innovative clean technological solutions. The Natural Resources Canada ecoENERGY Innovation Initiative (ecoEII) funds research and development to reduce barriers to the deployment of renewables. As one of the highlights, Canada reported that the Toronto and Region Conservation Authority (TRCA) established the Kortright Energy Yield Test Standard to increase the reliability and optimized performance of PV systems.

France allocated 9,3 MUSD in 2014. Its R&D activities are implemented through agencies under the government's supervision, such as ADEME (French Environment and Energy Management Agency), ANR (French National Research Agency) and Bpifrance (organization providing support to SME-SMIs for their innovation projects) and cover upstream studies (ANR's programme) to finalized projects (AMI PV programme from ADEME) and industrial prototypes (re-industrialization support programme of Bpifrance). About 40 research teams and practically all manufacturers of PV materials and PV components are involved in R&D programmes under private–public partnerships.

R&D budget for 2014 in Denmark was 5,3 MUSD, almost the same level of the previous year. Focused areas are: organic dye sensitized PV cells (PEC), polymer cells and PV cells-architecture-lights. R&D efforts on nano-structured PV cells continued as well. Basic research in PV cells based on mono-X Si is also ongoing. A new small R&D&D programme of 20 MDKK targeting BIPV was agreed by end of 2012, and was minted out in the first half of 2013. About 10 R&D&D projects have received support.

Although the budget amount is not available, other IEA PVPS countries support R&D activities.

China reported that industrial mc-Si solar cell conversion efficiency was improved through optimized processing technology and using high efficiency silicon wafer. It also reported that efficiency of sc-Si cell increased to 19,5%-20% through PERC and MWT technologies. Improvement of PV modules efficiency, quality and efficiency of LS-PV plants were also observed. In addition to these improvements, China made efforts for high penetration distributed PV systems, design and control technology of multifunction invertors and measuring and controlling technology of distributed grid-connected PV/energy storage systems.

In Italy, R&D is mainly conducted by ENEA (the Italian Agency for New Technology, Energy and the Environment) and RSE (a research company owned by GSE. ENEA's focuses are: crystalline silicon cell, amorphous-crystalline silicon heterojunction cell, CZTS cell and CZTS/silicon Tandem cell, Perovskite single junction cell, Perovskite-silicon tandem cell, microcrystalline Si devices, micromorph tandem solar cell as well as concentrators technologies. In the field of PV systems ENEA is developing devices, software, modeling, smart grid concepts and strategies for optimum system integration in the electrical grid. Moreover, ENEA conducts research on materials and on electrochemical processes finalized to energy storage. RSE is carrying out activities on high efficiency multi-junction solar cells based on III-V-IV elements and nano-structured coating for high concentration applications. Furthermore, RSE is engaged in the performance evaluation of innovative flat modules and plants, as well as in research and demonstration activities for electrification of remote communities.

In Switzerland more than 70 projects, supported by various national and regional government agencies, the European Commission and the private sector, were conducted. Innovative solutions, cost reduction, increased efficiency and reliability, industrial viability and transfer as well as adequate market orientation are the main objectives of the technical R&D. For solar cells, the previous strong focus on thin-film solar cells is diversifying with projects in a wider variety of materials (crystalline silicon, amorphous and microcrystalline silicon, compound semiconductors, dyesensitised, perovskite and organic solar cells), public budgets for market stimulation, demonstration/field test programmes and R&D.

In Malaysia, R&D activities are conducted under the Ministry of Science, Technology and Innovation. Most of the projects are conducted by universities and TNB Research, a research institute of utility. Research topics range from solar cells to system application technologies such as monitoring, forecasting technologies and reliability issues in tropical conditions.

Thailand reported that it has 4 focused areas: solar cells and related materials (silicon ingot, TCO glass, thin-film Si and CIGS, and organic and dye sensitized cells), PV components (grid and stand-alone hybrid systems inverters), PV applications (systems evaluation) and PV hybrid systems and techno socio-economic management of PV systems in rural areas. It also reported that the Thailand solar PV roadmap initiative was developed through recent research efforts on PV policy. While companies focus on improving their productivity of both solar cells and modules as well as PV power systems evaluation, universities and institutes are working on building a knowledge base, e.g. on analyzing the performance and degradation of PV systems under tropical condition.

The European Commission promotes PV research and development. In 2014, The EU's 7th Framework Programme for Research, FP7 (2007 - 2013), has run for seven years and is now concluded. Total 258,7 MUSD (195,0 MEURO) were allocated for the R&D projects on wafer-based-Si, thin-films, new concept, production equipment & process, CPV, building integration, installations & grid interconnection, and horizontal activities/infrastructures. In 2014, a new EU framework programme, "Horizon 2020 (2014-2020)" started. Under the area of "Secure, Clean and Efficient Energy", about 5,9 BEUR is allocated to a reliable, affordable, publicly accepted, sustainable and competitive energy system. The "Call Competitive Low-carbon Energy" of the Energy Challenge published in December 2013 covers the period 2014-2015 and addresses four PV specific challenges divided into two more general topics: LCE 2 (Developing the next generation technologies of renewable electricity and heating/cooling) and LCE 3 (Demonstration of renewable electricity and heating/cooling technologies).

Outside the PVPS member countries, R&D activities are conducted in PV cell/module producing countries such as Taiwan, Singapore and India. Solar research institutes are also established in emerging PV market such as Saudi Arabia and Chile.

PV powered townhome © Dennis Schroeder / NREL

# five

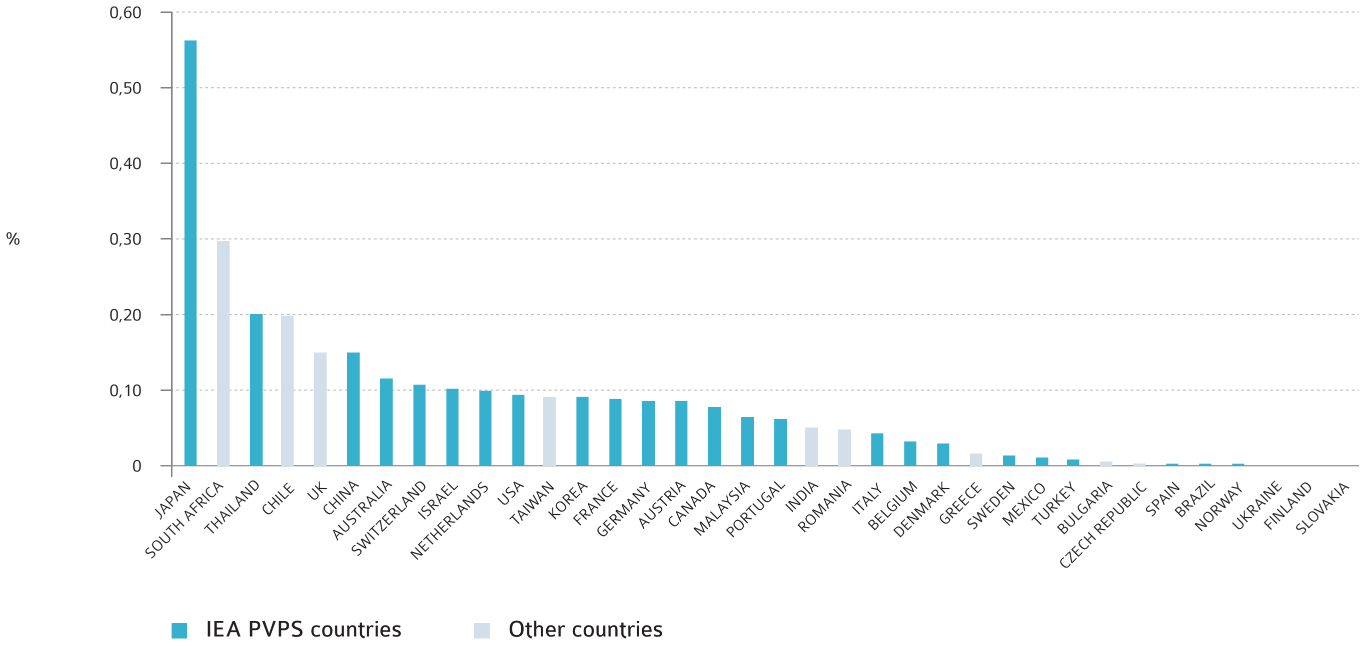
## PV AND THE ECONOMY

## VALUE FOR THE ECONOMY

The slight growth of the PV installations in 2014 and the relative stability in prices, caused the business value of PV to remain at the same level of 2013 when the value of the business reached 82 BUSD.

Figure 18 shows the estimated business value for PV compared to GDP in IEA PVPS reporting countries and other 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 did not report a specific business value, this is estimated based on the average PV system price.

**FIGURE 18:** BUSINESS VALUE OF THE PV MARKET COMPARED TO GDP IN % IN 2014




SOURCE IEA PVPS.

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, such as China or Taiwan. The European and American markets, on the other hand, are net importers.

Denmark, Norway, Sweden, Canada and Switzerland are net exporters. In the case of Switzerland, the balance that was highly positive in 2012 and reduced in 2013, saw this trend reversing in 2014. In fact, 413 MCHF of exports compensated some 230 MCHF of imports. Other countries, such as Germany, France and Italy, with less industrial players and/or a large PV market in 2014, reduced the business value of PV due to imports.

### O&M

The turnover linked to Operation and Maintenance is not considered in detail, given the variety of existing maintenance contracts and costs. Although, one might estimate the global turnover related to O&M in the PV sector around 5,3 BUSD per year assuming an annual recurrent cost of 30 USD/kWp.

### CONTRIBUTION TO THE GDP

The business value of PV should be compared to the GDP of each country. In 2014, the business value of PV represents less than 0,5% in all countries considered, as can be noticed in Figure 18. The PV business value 0,56% of the Japanese GDP in 2014, is up from 0,23% in 2013. Japan is then followed by two developing countries, South Africa and Thailand, for which the PV business covered in 2014 respectively 0,30% and 0,20% of their GDP.

## 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.

PV labour places are evolving rapidly in several countries due to the changes in the PV markets and industry. The decrease of the market in several key European countries has quickly pushed the installation jobs down while some other countries, where the market was growing, experienced an opposite trend.

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 in 2014. However, industrial jobs went up again in 2014 where manufacturing increased.

In general, the evolution of employment is linked to the industry and market development, with important differences from one country to another due to local specifics. It remains difficult to estimate the number of jobs created by the development of PV since a part of them stands in the upstream and downstream sectors of the value chain, mixed with others.

**TABLE 8:** EMPLOYMENT IN IEA PVPS REPORTING COUNTRIES

| COUNTRY | LABOUR PLACES | DIFFERENCE WITH 2013 |
|---|---|---|
| AUSTRALIA | 14 620 | 25% |
| AUSTRIA | 3 213 | -34% |
| CANADA | 8 100 | 37% |
| FRANCE | 9 400 | -23% |
| ITALY | 12 000 | 20% |
| JAPAN | 126 000 | 24% |
| MALAYSIA | 11 500 | 8% |
| NORWAY | 774 | - |
| SPAIN | 7 500 | - |
| SWEDEN | 721 | 10% |
| SWITZERLAND | 5 800 | -9% |
| USA | 173 807 | 22% |

SOURCE IEA PVPS.


Aerial of SolarTAC test facility in Aurora, Colorado. © Dennis Schroeder / NREL

The fast price decline that PV experienced in the last years opens possibilities to develop PV systems in some locations with limited or no financial incentives. However, the road to full 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 several 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 at www.iea-pvps.org.

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

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

In 2014, the lowest system prices in the off-grid sector, irrespective of the type of application, typically ranged from about 2 USD/W to 24 USD/W. The large range of reported prices in Table 9 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 2014 also varied between countries as shown in Table 9. The average price of these systems is tied to the segment. 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. In summary, system prices continued to go down in 2014, in spite of module prices stagnation, through a decrease in soft costs and margins, but the highest prices went down faster than the lowest ones. The variations of currency exchange rates in 2014 made price comparisons more complex. However, system prices below 1 USD/Wp for large-scale PV systems seem to be now common in very competitive tenders. The range of prices tends to converge, with the lowest prices decreasing at a reduced rate while the highest prices are reducing faster. Prices for small rooftops, especially in the residential segment continued to decline in 2014 in several countries. However, higher prices are still observed depending on the market. For instance, the prices in the USA and Japan continued to be higher than for the same type of rooftop installation in Germany.

**TABLE 9:** INDICATIVE INSTALLED SYSTEM PRICES IN CERTAIN IEA PVPS REPORTING COUNTRIES IN 2014

| | OFF-GRID (LOCAL CURRENCY OR USD PER W) | | | | GRID-CONNECTED (LOCAL CURRENCY OR USD PER W) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | <1 kW | | >1 kW | | RESIDENTIAL | | COMMERCIAL | | INDUSTRIAL | | GROUND-MOUNTED | |
| COUNTRY | LOCAL CURRENCY/W | USD/W | LOCAL CURRENCY/W | USD/W | LOCAL CURRENCY/W | USD/W | LOCAL CURRENCY/W | USD/W | LOCAL CURRENCY/W | USD/W | LOCAL CURRENCY/W | USD/W |
| AUSTRALIA | 9,00 - 15,00 | 8,14 - 13,56 | 7,50 - 11,00 | 6,78 - 9,94 | 1,95 | 1,76 | 1,78 | 1,61 | 1,80 | 1,63 | 1,80 | 1,63 |
| AUSTRIA | 5,00 | 6,67 | 5,00 | 6,67 | 1,75 | 2,33 | 1,47 | 1,96 | NA | - | NA | - |
| CANADA | NA | - | NA | - | 3,00 - 4,00 | 2,73 - 3,64 | 2,90 | 2,64 | 2,20 | 2,00 | 2,00 - 2,60 | 1,82 - 2,37 |
| DENMARK | 15,00 - 30,00 | 2,68 - 5,36 | 25,00 - 50,00 | 4,47 - 8,94 | 10,00 - 18,00 | 1,79 - 3,22 | 10,00 - 20,00 | 1,79 - 3,58 | 10,00 - 15,00 | 1,79 - 2,68 | 8,00 - 10,00 | 1,43 - 1,79 |
| FRANCE | NA | - | NA | - | 3,00 - 4,00 | 4,00 - 5,33 | 2,10 - 2,40 | 2,80 - 3,20 | NA | - | 1,20 - 1,40 | 1,60 - 1,87 |
| GERMANY | NA | - | NA | - | 1,60 | 2,13 | 1,24 | 1,65 | NA | - | 1,00 | 1,33 |
| ITALY | NA | - | NA | - | 1,45 - 1,89 | 1,93 - 2,52 | NA | - | NA | - | 0,92 - 1,14 | 1,23 - 1,52 |
| JAPAN | NA | - | NA | - | 366,00 | 3,47 | NA | - | NA | - | 263,00 | 2,50 |
| MALAYSIA | NA | - | NA | - | 8,50 | 2,60 | 8,00 | 2,45 | 7,50 | 2,30 | 6,00 | 1,84 |
| NORWAY | 60,00 - 100,00 | 9,60 - 16,00 | 70,00 - 150,00 | 11,20 - 24,00 | 20,00 | 3,20 | 16,00 | 2,56 | - | - | - | - |
| SPAIN | 4,80 | 6,40 | 3,80 | 5,07 | 2,20 | 2,93 | 1,50 | 2,00 | 1,20 | 1,60 | 1,20 | 1,60 |
| SWEDEN | 25,00 | 3,68 | 20,40 | 3,00 | 19,23 | 2,83 | 12,90 | 1,90 | NA | - | NA | - |
| SWITZERLAND | 6,00 - 15,00 | 6,59 - 16,47 | 4,00 - 12,00 | 4,39 - 13,17 | 2,50 - 4,50 | 2,74 - 4,94 | 2,00 - 3,00 | 2,20 - 3,29 | 1,90 | 2,09 | NA | NA |
| THAILAND | 65,00 - 85,00 | 2,00 - 2,61 | 65,00 - 85,00 | 2,00 - 2,61 | 60,00 - 100,00 | 1,84 - 3,07 | 50,00 - 85,00 | 1,53 - 2,61 | 55,00 - 75,00 | 1,69 - 2,31 | 40,00 - 60,00 | 1,23 - 1,85 |
| USA | NA | - | NA | - | 4,61 | 4,61 | 3,44 | 3,44 | NA | - | 1,77 | 1,77 |

**NOTE:** DATA REPORTED IN THIS TABLE DO NOT INCLUDE VAT.

SOURCE IEA PVPS.

## MODULE PRICES

On average, the price of PV modules in 2014 (shown in Table 10) accounted for approximately 40% of the lowest achievable prices that have been reported for grid-connected systems. In 2014, the lowest price of modules in the reporting countries was about 0,61 USD/W registered in China, up from 0,52 USD/W registered in Australia in 2013.

**TABLE 10:** INDICATIVE MODULE PRICES (NATIONAL CURRENCY/WATT AND USD/WATT) IN SELECTED REPORTING COUNTRIES

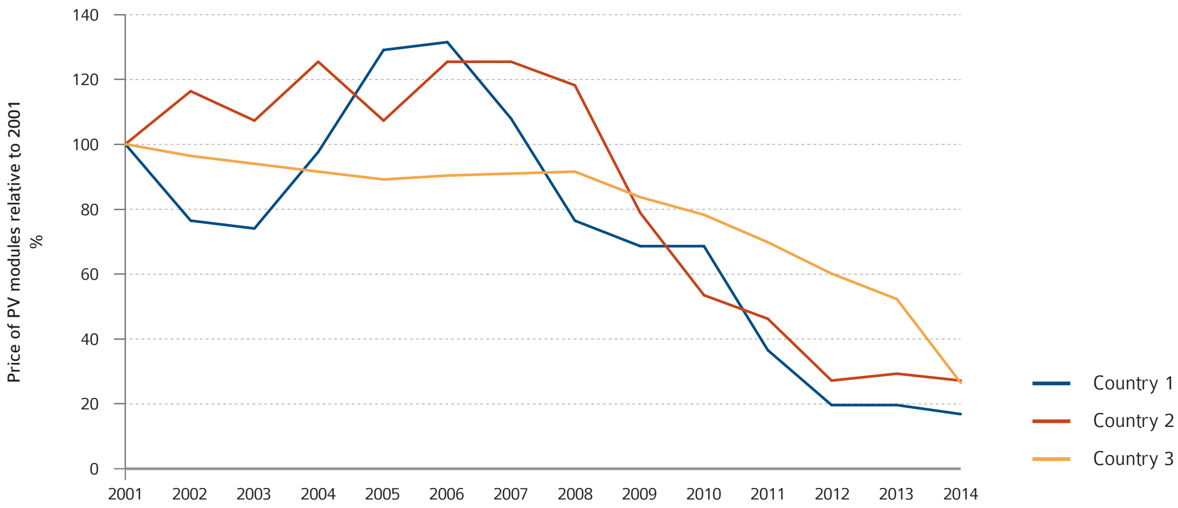
| COUNTRY | CURRENCY | LOCAL CURRENCY/W | USD/W |
|---|---|---|---|
| AUSTRALIA | AUD | 0,8 | 0,7 |
| AUSTRIA | EUR | 0,6 - 0,67 | 0,8 - 0,9 |
| CANADA | CAD | 0,85 | 0,8 |
| CHINA | CNY | 3,75 | 0,61 |
| DENMARK | DKK | 4 - 9 | 0,7 - 1,6 |
| FRANCE | EUR | 0,55 - 0,65 | 0,7 - 0,9 |
| GERMANY | EUR | 0,59 | 0,8 |
| ITALY | EUR | 0,55 | 0,7 |
| JAPAN | JPY | 197 | 1,9 |
| MALAYSIA | MYR | 3 | 0,9 |
| NORWAY | NOK | 10,8 | 1,7 |
| SPAIN | EUR | 0,6 | 0,8 |
| SWEDEN | SEK | 8,15 | 1,2 |
| SWITZERLAND | CHF | 0,95 | 1 |
| THAILAND | THB | 39 - 53 | 1,2 - 1,6 |
| USA | USD | 0,76 | 0,76 |

**NOTES:** DATA REPORTED IN THIS TABLE DO NOT INCLUDE VAT.
GREEN = LOWEST PRICE. RED = HIGHEST PRICE.

SOURCE IEA PVPS.

## SYSTEM PRICES / CONTINUED

**FIGURE 19:** EVOLUTION OF PV MODULES PRICES IN 3 INDICATIVE COUNTRIES (NORMALIZED TO 2001)

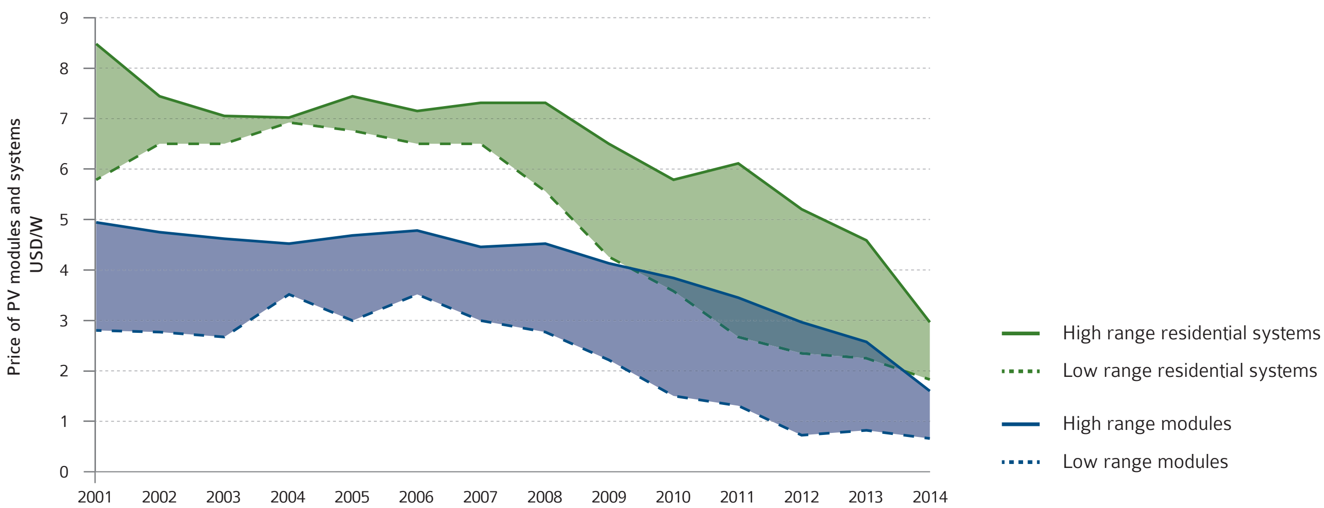



SOURCE IEA PVPS.

While many believe such a price was below the production cost, most reporting countries recorded lower module prices than in 2013.

After having experienced prices so low that many companies lost money in 2012 and 2013, PV modules prices decreased slightly in 2014 and even registered a slight increase in some countries for some products, especially the most competitive ones. Figure 19 shows the evolution of normalized prices for PV modules in selected key markets. Figure 20 shows the trends in actual prices of modules and systems in selected key markets. It shows that, unlike the modules, system prices continued to go down, at a slower pace.

**FIGURE 20:** EVOLUTION OF PV MODULES AND SMALL-SCALE SYSTEMS PRICES IN SELECTED REPORTING COUNTRIES 2001-2014 (2014 USD/W)




SOURCE IEA PVPS.

### COST OF PV ELECTRICITY

In order to compete in the electricity sector, PV technologies need to provide electricity at a cost equal to 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 nature of the installation and its size. However, it will also depend on the environment in which the system will operate. Off-grid applications in competition with diesel-based generation will not 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 type of PV system and its environment.

## GRID PARITY – SOCKET PARITY

*Grid Parity* (or *Socket Parity*) refers to the moment when PV can produce electricity (the Levelized Cost Of Electricity or 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 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.

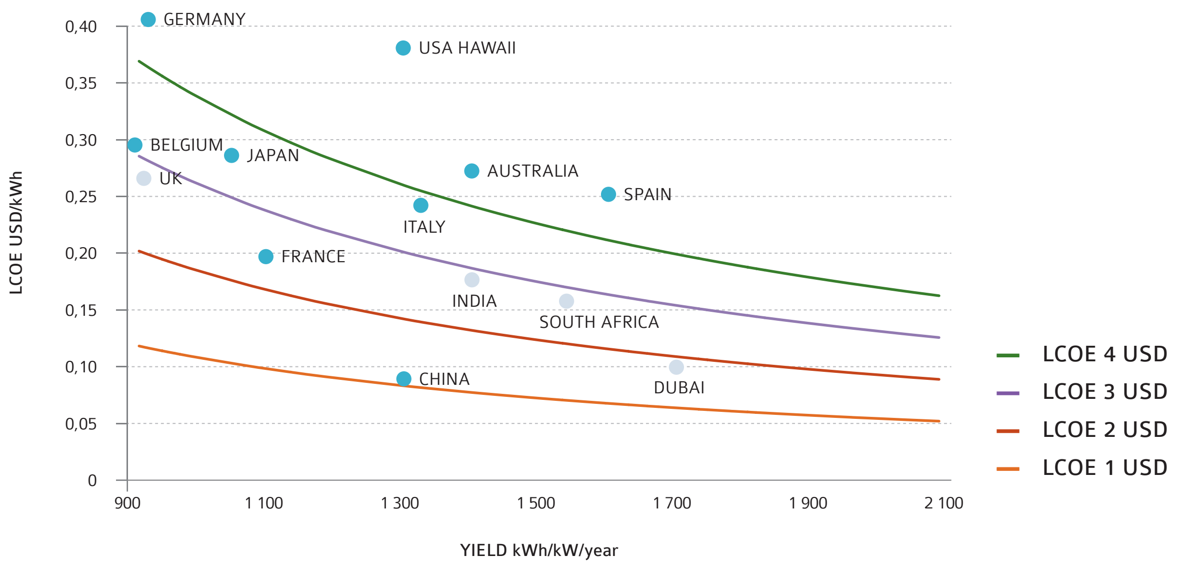
However, it is assumed that the level of self-consumption that can be achieved with a system that provides on a yearly basis up to the same amount of electricity as the local annual electricity consumption, varies between less than 30% (residential applications) and 100% (for some industrial applications)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

Technical solutions will allow for increases in the self-consumption level (demand-side management, local electricity 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 often guaranteed for small size installations by the possibility of receiving a FiT for the injected electricity. Nevertheless, if we consider how PV could become competitive, this will imply defining a way to price this 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:

**FIGURE 21:** LCOE OF PV ELECTRICITY AS A FUNCTION OF SOLAR IRRADIANCE & RETAIL PRICES IN KEY MARKETS*




***NOTE** THE COUNTRY YIELD (SOLAR IRRADIANCE) HERE SHOWN MUST BE CONSIDERED AN AVERAGE.

**SOURCE** IEA PVPS.

## GRID PARITY – SOCKET PARITY / CONTINUED

- 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; with tax loss on one side and the lack of financing of distribution and transmission grids on the other. 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 or a better understanding of PV positive impacts on the grid should be achieved.

### 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 organisation 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 competitive when PV 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.

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.

### RECORD TENDERS IN 2014

With several countries having adopted tenders as a way to allocate PPAs to PV projects, the value of these PPAs achieved record low levels in 2014 and in the first months of 2014. These levels are sufficiently low to be mentioned since they approach, or in some cases beat, the price of wholesale electricity in several countries. While these tenders do not represent the majority of PV projects, they have shown the ability of PV technology to provide extremely cheap electricity under the condition of a low system price (below 1 USD/Wp) and a low cost of capital. At the end of 2014, the record was 5,85 USDcents/kWh for a 200 $MW_{AC}$ PV project in Dubai. This project won the bid proposed by local authorities but has not been built yet. Many other winning bids globally reached a level in between 7 and 9 USDcents/kWh. Lower PPAs were granted in 2014 in the USA but with the help of the tax credit.

## COMMENTS ON GRID PARITY AND COMPETITIVENESS

Finally, the concept of Grid Parity remains an interesting benchmark but should not 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. However, considering the self-consumption and grid constraints, they have not 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 many others. The relatively high level of certainty during a long period of time should not 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) as well as hedging costs.

Seasonally adjusted fixed-axis photovoltaic panels at the SunEdison photovoltaic power plant near Alamosa, Colorado. © Steve Wilcox / NREL

# seven

## 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.

Italy remains the number one country with 8% of its electricity that will come from PV in 2015 based on 2014 installations. This number can be translated into 15 to 16% of the peak electricity demand. In Germany, with more than 6,7%, the 38,2 GW installed in the country produce up to 50% of the instantaneous power demand on some days, and around 13% of the electricity during the peak periods.

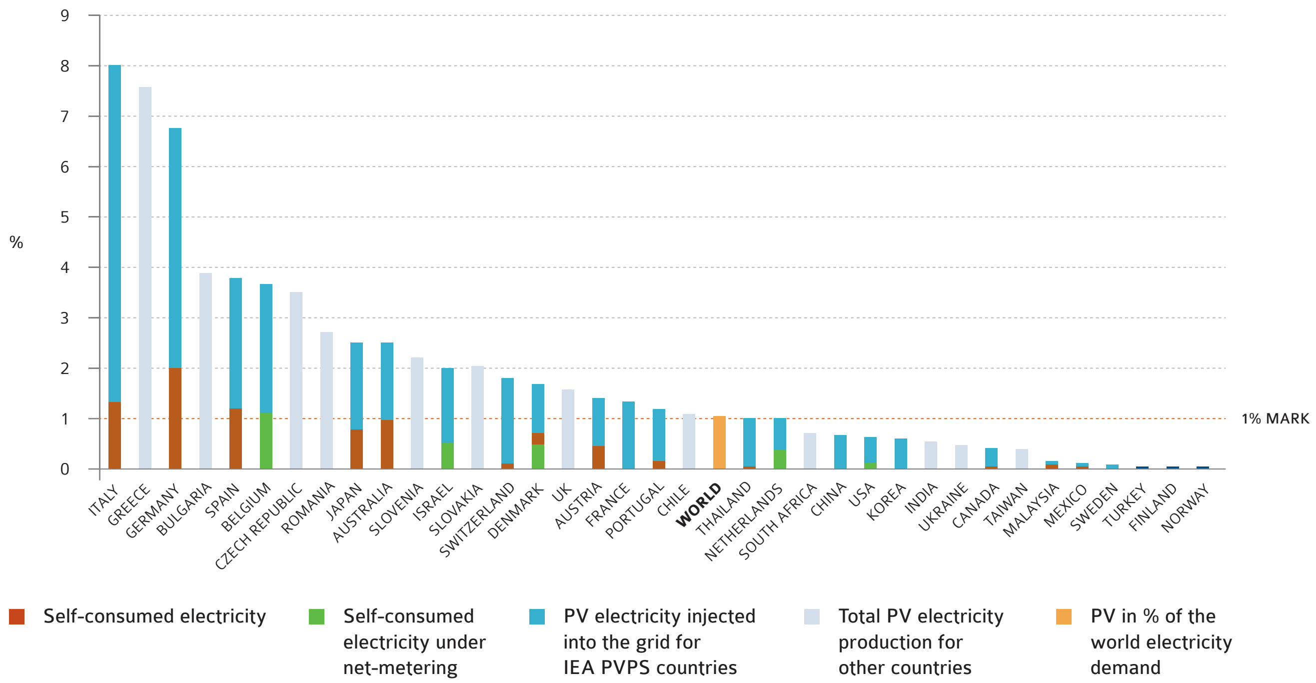
Three countries outside the IEA PVPS network have the ability to produce more than 3% of their electricity demand: Greece (around 7,6% based on the 2014 installed capacity), Bulgaria and the Czech Republic. Spain remains below the 4% mark as well as Belgium, which is producing 3,6% of its electricity thanks to PV. Romania, Japan, Australia, Slovenia and Israel are above the 2% mark. Switzerland, Denmark and the UK are approaching the 2% mark, while Austria, France, Portugal and Chile are still below the 1,5 % mark. In Thailand and the Netherlands in 2015, 1% of the electricity demand will be now covered by PV for the first year. Many other countries have lower production numbers.

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

- Estimated PV installed and commissioned capacity on 31.12.2014.
- 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.

## PV ELECTRICITY PRODUCTION / CONTINUED

### FIGURE 22: PV CONTRIBUTION TO THE ELECTRICITY DEMAND IN 2014




SOURCE IEA PVPS.

Figure 22 shows how PV theoretically contributes to the electricity demand in IEA PVPS countries, based on the PV base at the end of 2014.

### GLOBAL PV ELECTRICITY PRODUCTION

With around 177 GW installed all over the world, PV could produce around 210 TWh of electricity on a yearly basis. With the world's electricity consumption at 20 000 TWh in 2014, this represents slightly more than 1% of the electricity global demand covered by PV.

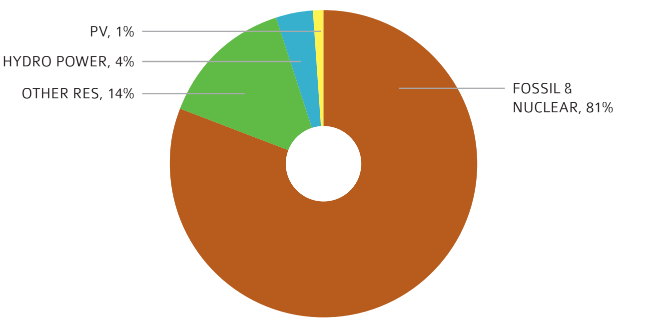
Figures 23 and 24 compare this number to other electricity sources, and especially renewables.

PV represents 27% of the world's installed capacity of renewables, excluding hydropower. In the last thirteen years in Europe, PV's installed capacity ranked third with 87 GW installed according to SolarPower Europe, after gas (101 GW) and wind (117 GW), ahead of all other electricity sources, while conventional coal and nuclear were decommissioned.

The trend is not so different outside Europe. In China, PV represented almost 10% of the new capacity installed in the country in 2014. In fact, China installed 103,5 GW of new power generation capacity, up from 94 GW in 2013.

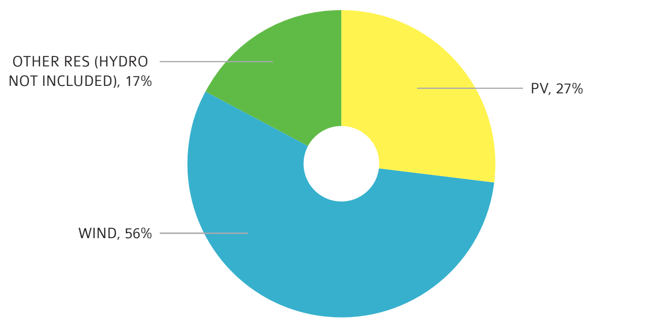
In 2014, Japan installed 16,8 GW up from 7,4 GW in 2013 of new power generation capacity, out of which 9,7 GW was from PV. As in 2013, the USA installed more than 17 GW of new power generation capacities of which 9,7 GW from renewables. With 6,2 GW installed, PV represented almost 36% of the new generation capacity added in 2014. In Australia, 1,44 GW of power generation capacity was installed in 2014, out of which 63% were PV systems.

## FIGURE 23: SHARE OF PV IN THE GLOBAL ELECTRICITY DEMAND IN 2014




SOURCE REN21, IEA PVPS.

## FIGURE 24: SHARE OF PV IN THE TOTAL RES INSTALLED CAPACITY IN 2014




SOURCE REN21, IEA PVPS.

## TABLE 11: PV ELECTRICITY STATISTICS IN IEA PVPS REPORTING COUNTRIES 2014

| COUNTRY | FINAL ELECTRICITY CONSUMPTION 2014 (TWH) | HABITANTS 2014 (MILLION) | GDP 2014 (BILLION USD) | SURFACE ($KM^2$) | PV INSTALLATIONS IN 2014 (MW) | PV CUMULATIVE INSTALLED CAPACITY 2014 (MW) | PV ELECTRICITY PRODUCTION (TWH) | 2014 INSTALLATIONS PER HABITANT (W/HAB) | CAPACITY PER HABITANT (W/HAB) | CAPACITY PER $KM^2$ ($KW/KM^2$) | PV PENETRATION (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AUSTRALIA | 228 | 24 | 1 454 | 7 692 024 | 904 | 4 130 | 5,8 | 38 | 176 | 1 | 2,5% |
| AUSTRIA | 57 | 9 | 436 | 83 879 | 159 | 787 | 0,8 | 19 | 93 | 9 | 1,4% |
| BELGIUM | 79 | 11 | 533 | 30 528 | 79 | 3 156 | 3,0 | 7 | 282 | 103 | 3,6% |
| CANADA | 511 | 36 | 1 787 | 9 984 670 | 633 | 1 904 | 2,2 | 18 | 54 | 0 | 0,4% |
| CHINA | 5 523 | 1 364 | 10 360 | 9 596 961 | 10 640 | 28 330 | 36,8 | 8 | 21 | 3 | 0,7% |
| DENMARK | 34 | 6 | 342 | 43 094 | 42 | 606 | 0,6 | 8 | 108 | 14 | 1,7% |
| FINLAND | 83 | 5,4 | 270,67 | 338424 | NA | 8 | 0,0 | 0 | 2 | 0 | 0,0% |
| FRANCE | 465 | 66 | 2 829 | 640 294 | 939 | 5 678 | 6,2 | 14 | 86 | 9 | 1,3% |
| GERMANY | 519 | 81 | 3 853 | 357 114 | 1 900 | 38 250 | 35,0 | 23 | 473 | 107 | 6,7% |
| ISRAEL | 49 | 8 | 304 | 22 072 | 200 | 681 | 1,0 | 24 | 83 | 31 | 2,0% |
| ITALY | 308 | 61 | 2 144 | 301 336 | 424 | 18 622 | 24,7 | 7 | 305 | 62 | 8,0% |
| JAPAN | 965 | 127 | 4 601 | 377 930 | 9 740 | 23 409 | 24,6 | 77 | 184 | 62 | 2,5% |
| KOREA | 478 | 50 | 1 410 | 99 828 | 909 | 2 398 | 3,0 | 18 | 48 | 24 | 0,6% |
| MALAYSIA | 119 | 30 | 327 | 330 803 | 88 | 168 | 0,2 | 3 | 6 | 1 | 0,2% |
| MEXICO | 234 | 124 | 1 283 | 1 964 375 | 67 | 179 | 0,3 | 1 | 1 | 0 | 0,1% |
| NETHERLANDS | 111 | 17 | 870 | 37 354 | 400 | 1 123 | 1,1 | 24 | 66 | 30 | 1,0% |
| NORWAY | 126 | 5 | 500 | 323 782 | 2 | 13 | 0,0 | 0 | 3 | 0 | 0,0% |
| PORTUGAL | 49 | 10 | 230 | 92 090 | 110 | 391 | 0,6 | 11 | 38 | 4 | 1,2% |
| SPAIN | 223 | 46 | 1 404 | 504 645 | 23 | 5 376 | 8,6 | 0 | 116 | 11 | 3,8% |
| SWEDEN | 136 | 10 | 571 | 450 295 | 36 | 79 | 0,1 | 4 | 8 | 0 | 0,1% |
| SWITZERLAND | 58 | 8 | 659 | 41 277 | 305 | 1 061 | 1,1 | 37 | 129 | 26 | 1,8% |
| THAILAND | 169 | 67 | 374 | 513 120 | 475 | 1 299 | 1,8 | 7 | 19 | 3 | 1,1% |
| TURKEY | 156 | 76 | 800 | 783 562 | 40 | 58 | 0,1 | 1 | 1 | 0 | 0,1% |
| USA | 3 869 | 319 | 17 419 | 9 371 175 | 6 211 | 18 317 | 23,8 | 19 | 57 | 2 | 0,6% |
| WORLD | 20 000 | 7 200 | - | 510 100 000 | 39 839 | 177 003 | 212,4 | 6 | 25 | 0,3 | 1,1% |

SOURCE IEA PVPS.

## 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 6% of the electricity demand, the behaviour of utilities can be seen as a mix of an opposition towards PV development and attempts to take part in the development of this new business. Companies such as E.ON have established subsidiaries to target the PV on rooftop customers but are delaying the start of their commercial operations. At the end of 2014, E.ON decided to split in two companies, with one of them focusing on renewable energy development. 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. Mid 2014, EDF-EN owned some 700 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 and restarted its activities with the aim to provide PV modules in 2015. The same subsidiary offers PV systems for small rooftop applications, commercial, industrial and agricultural applications. Two other major French energy actors are presented in the PV sector: ENGIE (formerly 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 should start to provide also its own products.

In Italy, the main utility, ENEL, owns a RES-focused subsidiary, ENEL GREEN POWER, which invests and builds utility-scale PV power plants all over the world, including in its home country. At the end of 2014, EGP had around 300 MW of PV power plants in operation. In addition, it produces in Italy thin-film multi-junction (composed of amorphous and microcrystalline silicon) PV modules through 3SUN, founded as joint venture with Sharp and STMicroelectronics and now totally owned by EGP.

In several European countries, small local utilities are taking a positive approach towards the development of PV, as in Sweden or Switzerland by proposing investment in PV plants in exchange of rebates on the electricity bills or free electricity. In Denmark, EnergiMidt made use of capital incentives for a couple of years for its customers willing to deploy PV.

In Japan, utilities are engaging into the development of PV systems across the country and have started using PV in their own facilities.

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 was quite intense in 2013, concerning the viability of net-metering schemes for PV. However, utilities are also sizing opportunities for business and are starting to offer products or to develop PV plants themselves. Third-party investment comes often from private companies disconnected from the utilities.

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 many more plants than older companies.

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, the validity of some of these data cannot be assured with the same level of confidence as for IEA PVPS member countries.

# CONCLUSION – A MAJOR ELECTRICITY SOURCE

The year 2014 experienced a renewed growth of the PV market and confirmed the Asian leadership on the PV market and industry. PV is entering rapidly into a new era where the PV market will be concentrated in countries with energy needs. Two of the top three markets in 2014 were located in Asia (China and Japan), followed by Europe as a whole and the USA market.

This trend should be confirmed again in 2015, with Asia consolidating the core of the PV market, followed by the Americas and Europe. With PV development occurring in Latin America, Africa and the Middle East, it becomes clear that in the short term, all continents will experience a sound PV development. It is important to note that new markets spots have popped up in many places around the world, from the Philippines to Dubai and Jordan or Panama and the Honduras, confirming the globalization trends.

In Asia, next to China and Japan, Thailand, Korea, Taiwan, the Philippines and many other countries are starting or continuing to develop. India will most probably become soon the fifth pole of PV development, if the plans to install 100 GW in the coming years are confirmed. The Americas are following at a slower pace, with Latin America starting to engage in PV development in Mexico, Peru, Brazil, Panama, Honduras and of course Chile, the number one market in the region in 2014.

The price decrease that has been experienced in the last years continued at a slower pace in 2014. It has brought several countries and market segments close to a certain level of competitiveness. This is true in Germany and Italy, where the retail price of electricity in several consumers segments is now higher than the PV electricity's production cost. This is also true in several other countries for utility-scale PV or hybrid systems. Competitive tenders have also paved the way for low PV electricity prices in several key markets. 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 plant announcements well above 500 MW. The 550 MW plant opened in 2014 in the US will be beaten in 2015 by a largest plant built in the US as well: with 579 $MW_{AC}$, it will be the largest ever. Each year, larger plants are connected to the grid and plans for even bigger plants are being disclosed. However, PV is not only on the rise in developed countries, it also 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 have 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 PV system reliability together with lowering 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 have shown in recent years, PV has the ability to continue progressing fast.

# ANNEXES

## PV MARKET STATISTICS FOR THE YEAR 2014

### ANNEX 1: CUMULATIVE INSTALLED PV CAPACITY (MW) FROM 1992 TO 2014

| COUNTRY | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | IEA PVPS COUNTRIES | | | | | | | | | | | | | |
| 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 | 3226,0 | 4130,1 |
| AUSTRIA | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 21,1 | 24,0 | 25,6 | 28,7 | 32,4 | 54,4 | 97,3 | 188,9 | 364,6 | 627,7 | 787,0 |
| BELGIUM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 23,7 | 108,5 | 647,7 | 1066,1 | 2105,4 | 2818,9 | 3077,2 | 3156,4 |
| CANADA | 1,0 | 1,2 | 1,5 | 1,9 | 2,6 | 3,4 | 4,5 | 5,8 | 7,2 | 8,8 | 10,0 | 11,8 | 13,9 | 16,8 | 20,5 | 25,8 | 32,7 | 94,6 | 281,1 | 558,3 | 827,0 | 1271,5 | 1904,1 |
| CHINA | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 19,0 | 23,5 | 42,0 | 52,1 | 62,1 | 70,0 | 80,0 | 100,0 | 140,0 | 300,0 | 800,0 | 3500,0 | 6700,0 | 17690,0 | 28330,0 |
| DENMARK | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1,6 | 1,9 | 2,3 | 2,7 | 2,9 | 3,1 | 3,2 | 4,6 | 7,1 | 16,7 | 407,7 | 563,3 | 605,6 |
| FINLAND* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0,3 | 0,7 | 1,0 | 1,3 | 1,9 | 2,4 | 2,9 | 4,9 | 6,9 | 8,4 | 8,4 | 8,4 | 8,4 |
| FRANCE | 1,8 | 2,1 | 2,4 | 2,9 | 4,4 | 6,1 | 7,6 | 9,1 | 11,3 | 13,9 | 17,2 | 21,1 | 24,2 | 25,9 | 36,8 | 71,5 | 112,9 | 370,2 | 1207,3 | 2967,4 | 4086,6 | 4738,7 | 5677,8 |
| GERMANY | 2,9 | 4,3 | 5,6 | 6,7 | 10,3 | 16,5 | 21,9 | 30,2 | 103,4 | 222,5 | 343,6 | 496,0 | 1165,4 | 2100,6 | 2950,4 | 4230,1 | 6193,1 | 10538,1 | 17956,4 | 25441,6 | 33045,6 | 36349,9 | 38249,9 |
| ISRAEL | 0 | 0 | 0 | 0 | 0 | 0,3 | 0,3 | 0,4 | 0,4 | 0,5 | 0,5 | 0,5 | 0,9 | 1,0 | 1,3 | 1,8 | 3,0 | 24,5 | 70,1 | 189,7 | 236,7 | 480,7 | 680,9 |
| 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 | 18197,5 | 18621,8 |
| 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 | 4913,9 | 6700,9 | 13669,0 | 23409,4 |
| KOREA | 0 | 0 | 1,7 | 1,8 | 2,1 | 2,5 | 3,0 | 3,5 | 4,0 | 4,7 | 5,4 | 6,0 | 8,5 | 13,5 | 35,8 | 81,2 | 356,8 | 523,7 | 650,3 | 729,1 | 959,1 | 1489,1 | 2398,1 |
| MALAYSIA | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0,5 | 0,6 | 0,8 | 1,1 | 1,5 | 2,5 | 26,8 | 79,3 | 167,8 |
| MEXICO | 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 | 20,7 | 21,7 | 25,0 | 30,6 | 40,1 | 52,1 | 112,1 | 179,1 |
| NETHERLANDS | 0 | 0,1 | 0,1 | 0,3 | 0,7 | 1,0 | 1,0 | 5,3 | 8,5 | 16,2 | 21,7 | 39,7 | 43,4 | 45,4 | 47,5 | 48,6 | 52,8 | 63,9 | 84,7 | 142,7 | 362,7 | 722,8 | 1122,8 |
| NORWAY | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5,8 | 6,1 | 6,2 | 6,4 | 6,6 | 6,9 | 7,3 | 7,7 | 8,0 | 8,3 | 8,7 | 9,1 | 9,5 | 10,0 | 10,6 | 12,8 |
| PORTUGAL | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2,0 | 2,0 | 2,0 | 4,0 | 15,0 | 56,0 | 99,0 | 135,0 | 169,0 | 228,0 | 281,0 | 391,1 |
| SPAIN | 0 | 0 | 1,1 | 1,1 | 1,1 | 1,1 | 1,1 | 2,3 | 2,3 | 4,5 | 7,9 | 13,0 | 27,2 | 55,2 | 166,8 | 777,8 | 3829,2 | 3848,3 | 4329,7 | 4791,8 | 5104,1 | 5353,8 | 5376,4 |
| SWEDEN | 0,8 | 1,1 | 1,3 | 1,6 | 1,8 | 2,1 | 2,4 | 2,6 | 2,8 | 3,0 | 3,3 | 3,6 | 3,9 | 4,2 | 4,9 | 6,3 | 7,9 | 8,8 | 11,5 | 15,8 | 24,1 | 43,2 | 79,4 |
| 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 | 47,7 | 73,2 | 110,3 | 211,1 | 437,0 | 756,0 | 1061,0 |
| THAILAND | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2,9 | 4,2 | 10,8 | 23,9 | 30,5 | 32,5 | 33,4 | 43,2 | 49,2 | 242,7 | 387,6 | 823,8 | 1298,5 |
| TURKEY | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0,1 | 0,3 | 0,6 | 1,0 | 1,5 | 2,0 | 2,5 | 3,0 | 3,7 | 4,7 | 5,7 | 6,7 | 11,7 | 17,7 | 57,7 |
| USA | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 119,0 | 198,0 | 303,0 | 463,0 | 761,0 | 1190,0 | 2040,0 | 3961,0 | 7330,0 | 12106,0 | 18317,0 |
| TOTAL IEA PVPS | 46,0 | 59,8 | 85,4 | 104,9 | 133,0 | 180,5 | 238,9 | 343,7 | 572,7 | 843,2 | 1197,0 | 1629,6 | 2770,2 | 4159,5 | 5600,7 | 8101,5 | 14515,1 | 21924,6 | 36641,2 | 64329,2 | 88994,8 | 121695,2 | 156022,7 |
| TOTAL NON IEA PVPS | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1,1 | 2,2 | 3,4 | 16,5 | 29,1 | 33,5 | 38,3 | 48,7 | 134,6 | 767,5 | 2841,8 | 5417,6 | 9921,9 | 15468,1 | 20980,0 |
| TOTAL | 46,0 | 59,8 | 85,4 | 104,9 | 133,0 | 180,5 | 238,9 | 343,7 | 573,8 | 845,4 | 1200,4 | 1646,1 | 2799,3 | 4193,1 | 5639,0 | 8150,2 | 14649,7 | 22692,1 | 39483,1 | 69809,8 | 98916,7 | 137163,4 | 177002,7 |

* DATA CONCERNING THE PV MARKET IN FINLAND WAS PROVIDED BY SOLARPOWER EUROPE.

**SOURCE** IEA PVPS, BECQUEREL INSTITUTE, CREARA, RTS CORPORATION, SOLARPOWER EUROPE, WERNER CH., ET AL., 2015.

### ANNEX 2: ANNUAL INSTALLED PV CAPACITY (MW) FROM 1992 TO 2014

| COUNTRY | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | IEA PVPS COUNTRIES | | | | | | | | | | | | | |
| AUSTRALIA | 7,3 | 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 | 811,0 | 904,1 |
| AUSTRIA | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 21,1 | 3,0 | 1,6 | 3,1 | 3,7 | 22,0 | 42,9 | 91,7 | 175,7 | 263,1 | 159,3 |
| BELGIUM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 23,7 | 84,8 | 539,3 | 418,4 | 1039,3 | 713,5 | 258,4 | 79,2 |
| CANADA | 1,0 | 0,3 | 0,3 | 0,4 | 0,7 | 0,8 | 1,1 | 1,4 | 1,3 | 1,7 | 1,2 | 1,8 | 2,0 | 2,9 | 3,7 | 5,3 | 6,9 | 61,9 | 186,6 | 277,2 | 268,7 | 444,5 | 632,6 |
| CHINA | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 19,0 | 4,5 | 18,5 | 10,1 | 10,0 | 7,9 | 10,0 | 20,0 | 40,0 | 160,0 | 500,0 | 2700,0 | 3200,0 | 10990,0 | 10640,0 |
| DENMARK | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1,6 | 0,3 | 0,4 | 0,4 | 0,2 | 0,2 | 0,1 | 1,4 | 2,5 | 9,6 | 391,0 | 155,6 | 42,3 |
| FINLAND* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0,3 | 0,4 | 0,3 | 0,3 | 0,6 | 0,5 | 0,6 | 2,0 | 2,0 | 1,5 | 0 | 0 | NA |
| FRANCE | 1,8 | 0,3 | 0,3 | 0,5 | 1,5 | 1,7 | 1,5 | 1,5 | 2,2 | 2,6 | 3,3 | 3,9 | 3,1 | 1,7 | 10,9 | 34,7 | 41,4 | 257,3 | 837,1 | 1760,1 | 1119,2 | 652,1 | 939,1 |
| GERMANY | 2,9 | 1,4 | 1,3 | 1,1 | 3,6 | 6,2 | 5,4 | 8,3 | 73,2 | 119,1 | 121,0 | 152,4 | 669,4 | 935,2 | 849,7 | 1279,8 | 1963,0 | 4345,0 | 7418,3 | 7485,2 | 7604,0 | 3304,3 | 1900,0 |
| ISRAEL | 0 | 0 | 0 | 0 | 0 | 0,3 | 0 | 0,1 | 0 | 0 | 0 | 0 | 0,4 | 0,2 | 0,3 | 0,5 | 1,2 | 21,5 | 45,6 | 119,6 | 46,9 | 244,0 | 200,0 |
| ITALY | 3,1 | 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 | 1747,2 | 424,3 |
| JAPAN | 19,0 | 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 | 1786,9 | 6968,1 | 9740,4 |
| 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 | 45,3 | 275,7 | 166,8 | 126,7 | 78,8 | 230,0 | 530,0 | 909,0 |
| MALAYSIA | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0,5 | 0,2 | 0,1 | 0,3 | 0,5 | 1,0 | 24,3 | 52,5 | 88,5 |
| 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 | 9,5 | 12,0 | 60,0 | 67,0 |
| NETHERLANDS | 0 | 0,1 | 0,1 | 0,2 | 0,4 | 0,3 | 0 | 4,3 | 3,2 | 7,7 | 5,5 | 18,0 | 3,7 | 2,0 | 2,1 | 1,1 | 4,2 | 11,1 | 20,8 | 58,0 | 220,0 | 360,1 | 400,0 |
| NORWAY | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5,8 | 0,3 | 0,2 | 0,2 | 0,2 | 0,3 | 0,4 | 0,4 | 0,3 | 0,4 | 0,3 | 0,4 | 0,4 | 0,5 | 0,6 | 2,2 |
| PORTUGAL | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2,0 | 0 | 0 | 2,0 | 11,0 | 41,0 | 43,0 | 36,0 | 34,0 | 59,0 | 53,0 | 110,1 |
| SPAIN | 0 | 0 | 1,1 | 0 | 0 | 0 | 0 | 1,1 | 0 | 2,3 | 3,4 | 5,1 | 14,2 | 28,1 | 111,6 | 611,0 | 3051,4 | 19,2 | 481,3 | 462,2 | 312,2 | 249,7 | 22,6 |
| SWEDEN | 0,8 | 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 | 8,3 | 19,1 | 36,2 |
| SWITZERLAND | 4,7 | 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 | 100,8 | 225,9 | 319,0 | 305,0 |
| THAILAND | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2,9 | 1,3 | 6,6 | 13,1 | 6,6 | 2,0 | 0,9 | 9,8 | 6,1 | 193,5 | 144,9 | 436,2 | 474,7 |
| TURKEY | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0,1 | 0,2 | 0,3 | 0,4 | 0,5 | 0,5 | 0,5 | 0,5 | 0,7 | 1,0 | 1,0 | 1,0 | 5,0 | 6,0 | 40,0 |
| USA | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 119,0 | 79,0 | 105,0 | 160,0 | 298,0 | 429,0 | 850,0 | 1921,0 | 3369,0 | 4776,0 | 6211,0 |
| TOTAL IEA PVPS | 40,6 | 13,8 | 25,6 | 19,5 | 28,1 | 47,5 | 58,5 | 104,8 | 229,0 | 270,5 | 353,8 | 432,5 | 1140,7 | 1389,3 | 1441,2 | 2500,8 | 6413,5 | 7409,9 | 14717,6 | 27754,9 | 24602,7 | 32700,4 | 34327,5 |
| TOTAL NON IEA PVPS | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1,1 | 1,1 | 1,2 | 13,2 | 12,5 | 4,5 | 4,8 | 10,4 | 85,9 | 632,9 | 2074,3 | 2575,8 | 4504,2 | 5546,3 | 5511,9 |
| TOTAL | 40,6 | 13,8 | 25,6 | 19,5 | 28,1 | 47,5 | 58,5 | 104,8 | 230,1 | 271,6 | 355,0 | 445,7 | 1153,2 | 1393,8 | 1446,0 | 2511,2 | 6499,5 | 8042,8 | 16791,9 | 30330,7 | 29106,9 | 38246,6 | 39839,4 |

* DATA CONCERNING THE PV MARKET IN FINLAND WAS PROVIDED BY SOLARPOWER EUROPE.

**SOURCE** IEA PVPS, BECQUEREL INSTITUTE, CREARA, RTS CORPORATION, SOLARPOWER EUROPE, WERNER CH., ET AL., 2015.

## ANNEX 3: REPORTED PRODUCTION OF PV MATERIALS, CELLS AND MODULES IN 2014 IN SELECTED IEA PVPS COUNTRIES

| | | | | | | | | | MODULE PRODUCTION (MW) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| COUNTRY[1] | SOLAR PV GRADE SI FEEDSTOCK PRODUCTION (TONNES) | SOLAR PV GRADE SI FEEDSTOCK PRODUCTION CAPACITY (TONNES/YEAR) | PRODUCTION OF INGOTS (TONNES) | INGOTS PRODUCTION CAPACITY (TONNES/ YEAR) | PRODUCTION OF WAFERS (MW) | WAFER PRODUCTION CAPACITY (MW/YEAR) | CELL PRODUCTION (ALL TYPES, MW) | CELL PRODUCTION CAPACITY (MW/YEAR) | WAFER BASED (SC-SI & MC-SI) | THIN-FILM (A-SI & OTHER) | MODULE PRODUCTION CAPACITY (ALL TYPES, MW/YEAR) |
| AUSTRALIA | | | | | | | | | >2,5 | | 60 |
| AUSTRIA | | | | | | | | | 74 | | 261 |
| CANADA | | NA | | | | | | | 778 | | 1 066 |
| CHINA | 136 000 | | - | | 38 000 | | 28 410 | 47 000 | 35 300 | 360 | 63 000 |
| DENMARK | | | | | | | | 2 | 3 | | 3 |
| FRANCE | | 300 | | 100 | | 115 | | 110 | | | 670 |
| GERMANY | | 53 980 | | NA | | 1 820 | | 2 323 | | | 3 821 |
| ITALY | | | | | | | | 60 | 38 | 190 | 690 |
| JAPAN | > 1 000 | 15 000 | 0 | | 1 200 | | 2 781 | 3 705 | 2 715 | 1 124 | 4 802 |
| KOREA[2] | 26 391 | 70 000 | | 3 450 | | 2 510 | 1 120 | 1 930 | 1 830 | | 3 630 |
| MALAYSIA | | NA | | NA | | NA | | 4 090 | | | 2 777 |
| NETHERLANDS[2] | | | | | 150 | | | | | | |
| NORWAY | 6 000 | 6 000 | 1 350 | | 280 | | | | | | |
| SPAIN | | NA | | | | | | | 350 | 75 | 425 |
| SWEDEN | | | | | | | | | 34 | | 100 |
| SWITZERLAND | | | | | | | | | | | 40 |
| THAILAND | | | | | | | 59 | 135 | 68 | 2 | 235 |
| USA | 49 059 | | | | 21 | | 875 | 1 225 | 523 | 475 | 1 419 |

**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 REPORTED FIGURES ARE FROM NATIONAL SURVEY REPORT 2013.

SOURCE IEA PVPS, RTS CORPORATION.

## ANNEX 4: AVERAGE 2014 EXCHANGE RATES

| COUNTRY | CURRENCY CODE | EXCHANGE RATE (1 USD =) |
|---|---|---|
| AUSTRALIA | AUD | 1,11 |
| AUSTRIA, BELGIUM, FINLAND, FRANCE, GERMANY, ITALY, THE NETHERLANDS, PORTUGAL, SPAIN | EUR | 0,75 |
| CANADA | CAD | 1,10 |
| CHINA | CNY | 6,16 |
| DENMARK | DKK | 5,59 |
| ISRAEL | NIS | 3,56 |
| JAPAN | JPY | 105,40 |
| KOREA | KRW | 1 051,49 |
| MALAYSIA | MYR | 3,27 |
| MEXICO | MXN | 13,22 |
| NORWAY | NOK | 6,25 |
| SWEDEN | SEK | 6,80 |
| SWITZERLAND | CHF | 0,91 |
| THAILAND | THB | 32,51 |
| TURKEY | TRY | 2,18 |
| UNITED STATES | USD | 1,00 |

SOURCE XE.

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## WHAT IS THE IEA PVPS?

The International Energy Agency (IEA), founded in 1974, is an autonomous body within the framework of the Organisation for Economic Cooperation and Development (OECD). The IEA carries out a comprehensive programme of energy cooperation among its 29 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, Finland, France, Germany, Israel, Italy, Japan, Korea, Malaysia, Mexico, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Thailand, Turkey and the United States of America. The European Commission, SolarPower Europe (former EPIA), the Solar Electric Power Association, the Solar Energy Industries Association and the Copper Alliance are also members.

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