IEA INTERNATIONAL ENERGY AGENCY

TRENDS 2016

IN PHOTOVOLTAIC APPLICATIONS

21ST EDITION 2016

Survey Report of Selected IEA Countries between 1992 and 2015

PVPS

PHOTOVOLTAIC
POWER SYSTEMS
PROGRAMME

Report IEA PVPS T1-30:2016

COVER IMAGE
The Denver International Airport (DIA) features a 2 MW PV system at sunset. DIA is now host to a second 1.6 MW array system. © DIA

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 21st international survey. It provides an overview of PV power systems applications, markets and production in the reporting countries and elsewhere at the end of 2015 and analyses trends in the implementation of PV power systems between 1992 and 2015. 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 2016 in Photovoltaic Applications", are valid at the time of publication. Please note that all figures have been rounded.

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FOREWORD

Welcome to the 21st edition of the international survey report on Trends in Photovoltaic (PV) Applications up to 2015, provided to you by the IEA PVPS Programme.

The "Trends Report" is one of our flagship publications and a worldwide reference regarding the global photovoltaic market development. 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. In contrast to 2014, 2015 has seen an impressive growth and acceleration of the global market deployment with about 50,7 GW of additional installed capacity, 26,5% above 2014, of which about 40 GW were installed in IEA PVPS member countries (2014: 34 GW). As in 2014, China, Japan and the USA lead this important growth, accounting for 33 GW of installed capacity in these 3 countries alone. 8 countries have installed more than 1 GW while another 7 countries have markets above 300 MW. The globally installed total PV capacity is estimated at roughly 228 GW at the end of 2015. Although the price reduction for PV systems has continued its trend for a slower decline in 2015, this year (2016) shows evidence of a more rapid cost reduction, in parallel with a trend towards higher overcapacities in the industry. Concerning PV generation costs and more precisely recently contracted power purchase agreements (PPAs), new record values of below 3 USDcents/kWh have been announced, confirming what is achievable today under very good market and solar resource conditions. The other side of the coin is the observation that large parts of the global PV market (78%) are still driven by financial incentives, accompanied by an increasing share of self-consumption or net-metering (15%) and about 6% of the market coming from competitive tenders.

Yet, in many regions of the world, PV is one of the least cost options for electricity generation from new renewable energy technologies. New business models such as third-party investments and similar PV-as-a-service proposals are being developed by different stakeholders. While PV markets continue their impressive growth, technology progresses rapidly as well with thin film technologies approaching efficiencies similar to those of crystalline silicon. In parallel, emerging PV cell concepts and novel designs lead the way where PV technology might be heading to in the future. The increasing variety of technologies, designs and appearances of PV modules open up new applications and opportunities. Grid and energy system integration issues are becoming important in countries with a high share of PV, making PV a growing player in the energy field as a whole. In summary, PV continues its impressive and dynamic development in technology, industry, applications, installed capacity, price and business models, providing great opportunities for many stakeholders along the value chain. Learn all about the details of this exciting development by reading through our 21st edition of the Trends Report!

Stefan Nowak
Chairman
IEA PVPS Programme

PV CONTINUES ITS IMPRESSIVE AND DYNAMIC DEVELOPMENT IN TECHNOLOGY, INDUSTRY, APPLICATIONS, INSTALLED CAPACITY, PRICE AND BUSINESS MODELS, PROVIDING GREAT OPPORTUNITIES FOR MANY STAKEHOLDERS ALONG THE VALUE CHAIN.

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PV system installed in California. © AstroPower

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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 94% 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 25%. 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 used to have lower conversion efficiencies than basic crystalline silicon technologies but this has changed in recent years. They are potentially less expensive to manufacture than crystalline cells. Thin-film materials commercially used are cadmium telluride (CdTe), and copper-indium-(gallium)-diselenide (CIGS and CIS). Amorphous and micromorph silicon (a-Si) used to have a significant market share but failed to follow both the price of crystalline silicon cells and the efficiency increase of other thin film technologies. In terms of efficiencies, in 2016, CdTe cells reached 22% in labs. 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 stable 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 22,8%. 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 16,8% (CdTe). CPV modules offer now efficiencies up to 38%.

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 is in the range of 95% to 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, Li-Ion) 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.

A 245 kilowatt thin-film CIS PV system on the Shell Solar factory in Camarillo, California © Shell Solar

two

PV MARKET DEVELOPMENT TRENDS

More than twenty years of PV market development have resulted in the deployment of more than 227 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 40% (for instance some grid regulations limit output to as little as 70% of the peak power from the PV system, but also higher DC/AC ratios reflect the evolution of utility-scale PV systems). 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 PV INSTALLED CAPACITY

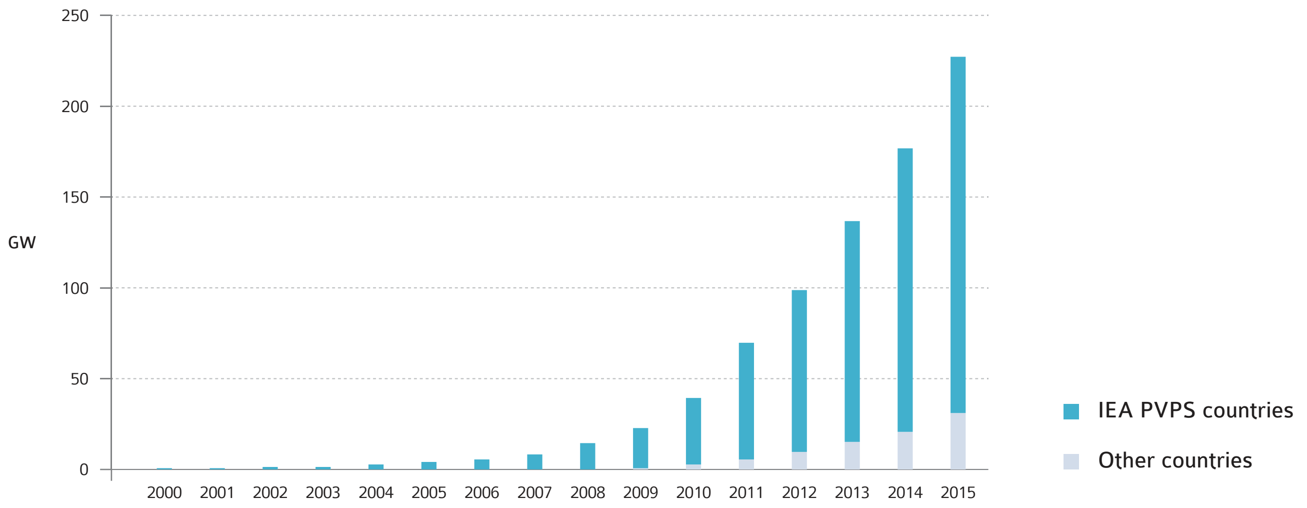
The IEA PVPS countries represented more than 196 GW of cumulative PV installations altogether, mostly grid-connected, at the end of 2015. The other 40 countries that have been considered and are not part of the IEA PVPS Programme represented 31 additional GW. An important part is located in Europe: UK with close to 10 GW, Greece with 2,6 GW, Czech Republic with 2,1 GW installed, Romania with 1,3 GW and Bulgaria with 1,0 GW and Ukraine and Slovakia below the GW mark. The other major countries that accounted for the highest cumulative installations at the end of 2015 are India with more than 5 GW, South Africa with 0,9 GW, Taiwan with 0,8 GW, Pakistan with an estimated 0,78 MW, Chile with 0,9 GW, Ukraine with 0,6 GW and Slovakia with 0,5 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 2015 outside the ones mentioned above: according to a paper released in 2016[1], 50 countries had at least 100 MW cumulative at the end of 2015 and 114 countries have more than 10 MW.

These numbers are based on recently verified PV shipments in countries outside of the traditional PV markets and show that at the end of 2015 an additional 31 GW of PV systems have been installed in the last years.

Presently it appears that 228 GW represents the minimum installed by end of 2015 with a firm level of certainty.

footnote 1 "Latest Developments in Global Installed Photovoltaic Capacity and Identification of Hidden Growth Markets", Werner Ch., Gerlach A., Masson G., Breyer Ch., 2016

FIGURE 1: EVOLUTION OF PV INSTALLATIONS (GW)



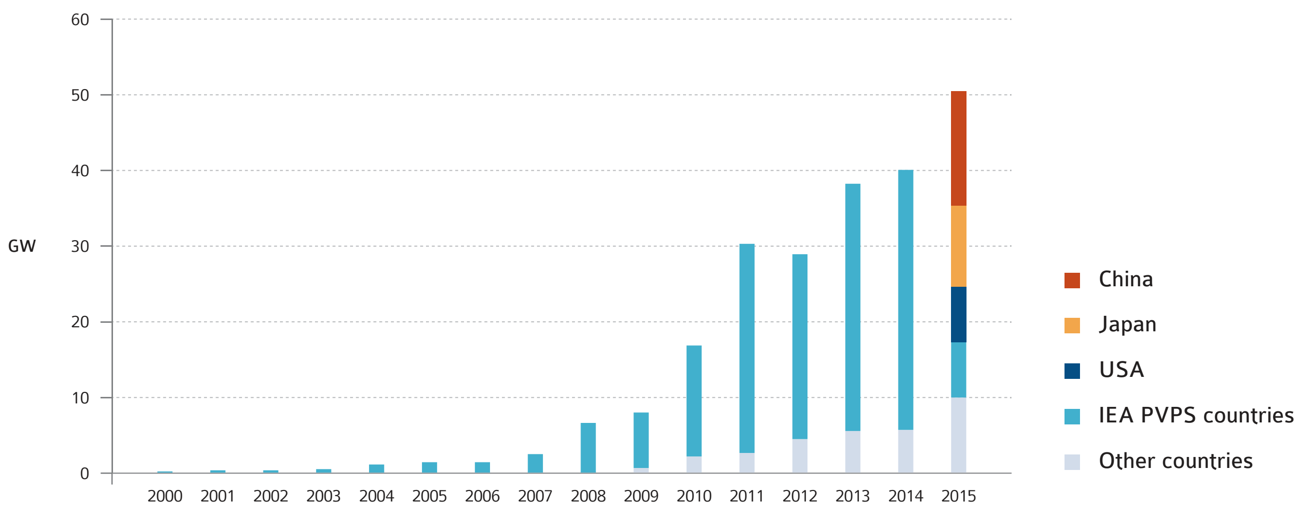
SOURCE IEA PVPS & OTHERS.

THE MARKET EVOLUTION

The 24 IEA PVPS countries installed at least 40,6 GW in 2015, with a worldwide installed capacity amounting to 50,7 GW. While they are hard to track with a high level of certainty, installations in non IEA PVPS countries contributed for 10 GW. The remarkable trend of 2015 is the significant growth of the global PV market after the small growth experienced during 2013 - 2014. With close to 51 GW, the market grew in 2015 by around 26,5%, again the highest installation ever for PV.

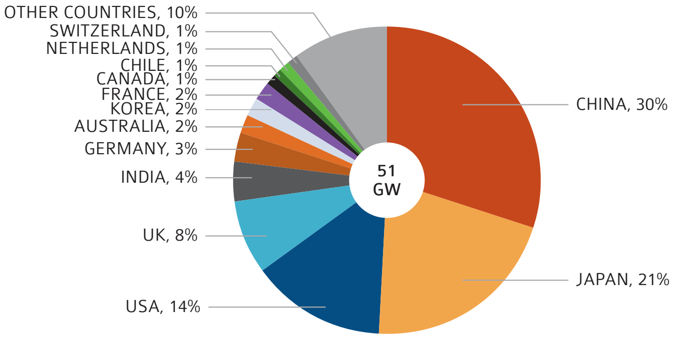
Just as in 2013 and 2014, China is in first place and installed 15,15 GW in 2015, according to the National Energy Administration; a record level significantly higher than the 10 GW that placed the country in the first place with regard to all time PV installations in 2013 and then in 2014. This is perfectly in line with their political will to develop renewable sources and in particular PV in the short to medium term. The total installed capacity in China reached 43,5 GW, and brings the country to first place, ahead of Germany for the first time.

FIGURE 2: EVOLUTION OF ANNUAL PV INSTALLATIONS (GW)



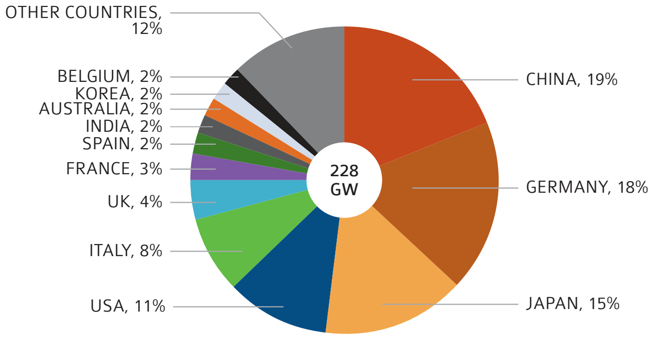
SOURCE IEA PVPS & OTHERS.

FIGURE 3: GLOBAL PV MARKET IN 2015



SOURCE IEA PVPS & OTHERS.

FIGURE 4: CUMULATIVE PV CAPACITY END 2015



SOURCE IEA PVPS & OTHERS.

The second place went once again to Japan, with 10,8 GW installed in the country in 2015, a slight growth rate compared to 2014, but a record-high year for the Japanese PV market.

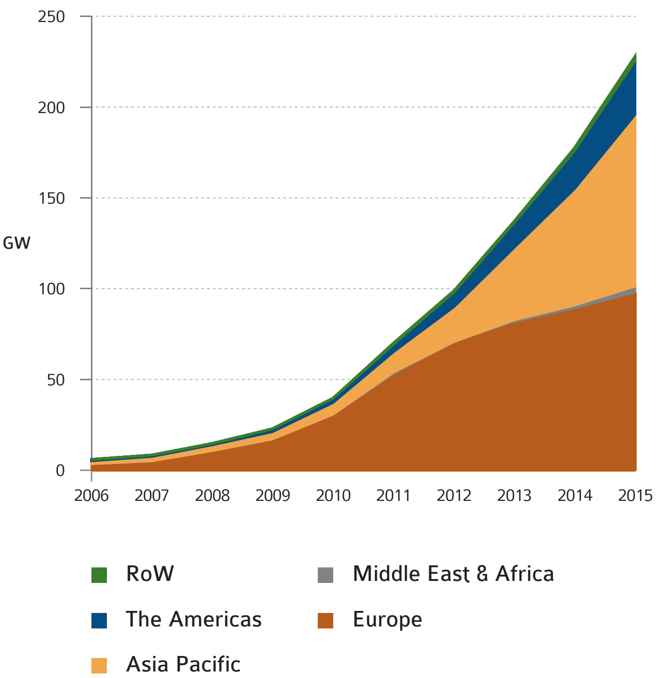
The USA installed 7,3 GW of PV systems in 2015, with a growing share of large utility-scale PV compared to rooftop installations.

The UK grew significantly in 2015 again, maintaining its position as the first country for PV installations in Europe with 4,1 GW.

The PV market's growth pushes India for the first time into the top 5 countries with 2,1 GW, amidst huge expectations for the years to come.

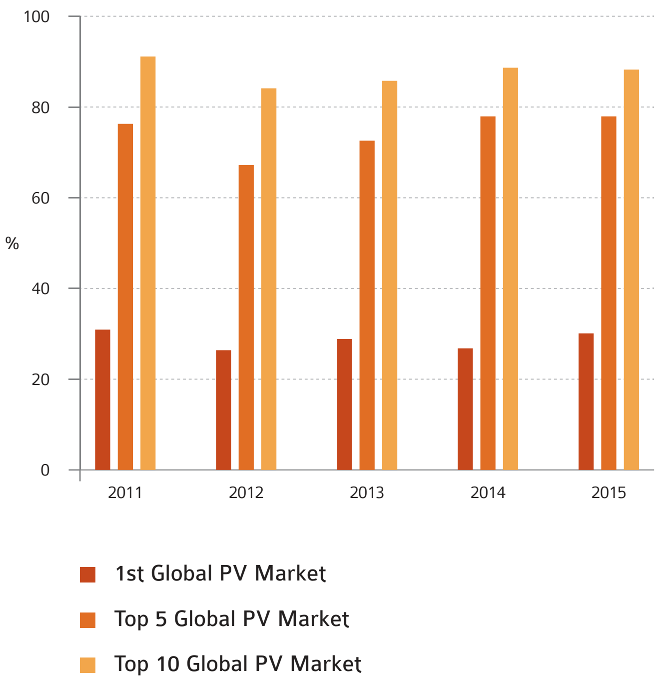
Together, these five countries represent 78% of all installations recorded in 2015 but only 52% in terms of installed capacity. In 2014, the top 5 countries represented 78% of 2014 installations and 72% of cumulative capacity. This shows the current market rebalancing, with many historical actors, such as Germany and Italy leaving the top 5 (and in the case of Italy the top 10) for annual installations. India and UK contributed to the top 5 in 2015 and are young markets, with significantly less cumulative capacity than former leaders.

FIGURE 5: EVOLUTION OF REGIONAL PV INSTALLATIONS (GW)



SOURCE IEA PVPS & OTHERS.

FIGURE 6: LARGEST PV MARKETS



SOURCE IEA PVPS & OTHERS.

THE MARKET EVOLUTION / CONTINUED

Germany continued to see its market declining: from 1,9 GW in 2014, the 2015 German PV market reached 1,46 GW, well below the 2008 level. After three years at levels of PV installations around 7,5 GW, the German PV market declined significantly. The total installed PV capacity is now just below the 40 GW mark, and is now ranked number two behind China.

Korea confirmed its market potential by installing 1 GW in 2015, after 926 MW the year before, and Australia installed slightly more than 1 GW (1022 MW).

No additional country installed more than 1 GW in 2015, showing that while the PV market reaches new countries, a very large part of the market remains concentrated in the hands of new countries. The following two places go to France (887 MW) and Canada (675 MW). Together these 10 countries cover 90% of the 2015 world market, a figure that has remained stable in the last years. Moreover, the level of installation required to enter the top 10 has decreased since 2013: from 810 MW, it went down to 675 MW in 2015, a sign that the growth of the global PV market has been driven by top countries, while others are contributing marginally, still in 2015.

Behind the top 10, some countries installed significant amounts of PV. With all necessary caution, Pakistan might have taken the 11th position with some 600 MW. However such numbers for Pakistan are difficult to establish without official statistics, and the real number might be different, since such numbers are based on shipments into the country which might not all have been already installed at the end of 2015. The Netherlands followed with 437 MW, together with Honduras (391 MW), Italy (300 MW), Algeria (268 MW), Turkey (208 MW) and Israel (205 MW). South Africa installed officially 38 MW, Thailand installed only 121 MW and Romania 102 MW.

Among these countries, some have already reached high PV capacities due to past installations. This is the case for Italy that tops 18,9 GW but also the Netherlands which has reached the 1,5 GW mark, Romania with 1,3 GW and Israel 886 MW.

Several other countries where the PV market used to develop in the last years, have performed in various ways. Belgium installed 97 MW and has reached more than 3,2 GW. Some countries that grew dramatically over recent years have now stalled or experienced limited additions: Spain (49 MWac) now totals 4,8 GWac of PV systems (respectively DC calculation 54 MWdc and 5,4 GWdc) followed by the Czech Republic at 2,1 GW.

In Denmark, the market experienced a rebound due to utility-scale installations while the distributed PV market that developed thanks to the net-metering scheme remained at a low level. Denmark installed a total of 181 MW. Austria continued at the same pace with 152 MW, compared to 159 MW one year before.

Malaysia installed 26,83 MW for the third year of its Feed-in Tariff (FiT) system. Taiwan installed 227 MW in a growing market now supported by pro-solar policymakers. The Philippines are developing their PV market which reached 110 MW for the first time in 2015 and many other countries in the region have started to implement PV policies.

In Latin America, official data for Chile shows the installation of 446 MW, after a second year of PV development, especially in the northern part of the country. Several additional GW of PV plants have been validated in Chile, while projects are popping up in Brazil and Honduras. Honduras installed 391 MW in 2015, but this outcome will not be repeated immediately. The real PV development of grid-connected PV plants has finally started and additional countries have installed dozens of MW, such as Guatemala (52 MW) and Uruguay (44 MW). Among the most promising prospects in the region, Mexico installed 56 MW but several GW have been granted to developers, which might transform the country into the very first GW-size market in Latin America.

In the Middle East, Israel progressed rapidly (205 MW), while the PV installations in Turkey have finally started. At the moment, the level of installation in 2015 (208 MW) does not reflect the expectations and promises which might become more concrete in 2016. With hundreds of MW of projects granted to super competitive tenders in Jordan or the UAE, the MENA region seems on the verge of becoming a new focal point for PV development, especially with the extremely low PPA granted there. Finally, Africa also sees PV deployment, with Algeria having installed 268 MW in 2015 and expecting more in 2016. South Africa commissioned around 38 MW after a rapid expansion in 2014 and more is already granted for the years to come. Many other countries are experiencing some PV development, from Morocco to Ghana or even Nigeria, but with double-digit MW markets.

AN INCREASINGLY 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 from 2013 to 2015. 7 of the top 10 leaders in 2012 are still present while the others have varied from one year to another. The UK entered the top 10 in 2013, Korea in 2014 and Canada in 2015. Greece left in 2013. Romania entered the top 10 in 2013 and left in 2014. France came back in 2014 and confirmed its position in 2015. South Africa entered briefly in 2014 and left already in 2015. The number of small-size countries with impressive and unsustainable market evolutions declined, especially in Europe but some booming markets in 2015 could experience a similar fate. For example, Honduras will have to affirm its standing. In 2014, only major markets reached the top 10, the end of a long term trend that has seen 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, as was confirmed in 2015. However, the required market level for entry into this top 10 that grew quite fast until 2012, has declined since then. In 2015, only 675 MW were necessary to reach the top 10, compared to 843 MW in 2012, while the global PV market surged from 30 to 50 GW at the same time. The number of GW markets that declined in 2014 to only five grew again to eight in 2015 and France was rather close to the GW at the ninth position. It can be seen as a fact that the growth of the PV market took place in countries with already well-established markets, while booming markets did not contribute significantly in 2015. In parallel for the first time, the downsizing of several European markets was compensated by the growth of new markets in Asia and America.

UTILITY-SCALE PROJECTS CONTINUE TO POP UP

The most remarkable trend of 2015 is again the announcement of extremely competitive utility-scale PV projects in dozens of new countries around the world and the confirmation that previous announcements were followed by real installations. 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, which triggers a significant decline in the value of PPAs and enlarges horizons for PV development. Utility-scale PV installations have surged significantly in 2015 with close to 32 GW compared to only 21 GW one year earlier. Many countries are proposing new tenders, including Germany, the UAE, Jordan, Brazil, Mexico 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	2013	2014	2015
1	CHINA	CHINA	CHINA
2	JAPAN	JAPAN	JAPAN
3	USA	USA	USA
4	GERMANY	UK	UK
5	ITALY	GERMANY	INDIA
6	UK	FRANCE	GERMANY
7	ROMANIA	KOREA	AUSTRALIA
8	INDIA	AUSTRALIA	KOREA
9	GREECE	SOUTH AFRICA	FRANCE
10	AUSTRALIA	INDIA	CANADA
MARKET LEVEL TO ACCESS THE TOP 10			
	810 MW	779 MW	675 MW

SOURCE IEA PVPS & OTHERS.

PROSUMERS, A DELAYED FUTURE

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, 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, as it can be seen in several countries, such as the USA. However the move towards self-consumption creates difficulties for the PV sector and the distributed PV market has been stable for three years now. It has been oscillating around 18-19 GW since 2013. While utility-scale PV develops, distributed PV experiences a real stagnation with little progress thus far. The US market can be seen as an exception, in the same way as several European PV markets that are currently transitioning towards self-consumption. However, the move towards distributed PV for prosumers has been delayed.

THE MARKET EVOLUTION / CONTINUED

LARGEST ADDITIONS EVER

The paradox of PV developing thanks to utility-scale installations is hidden by the remarkable progress of many markets. Italy's record of 9,3 GW yearly installed power was beaten in 2013 by China with its 10,95 GW; but also by Japan in 2015 with 11 GW. And even more by China in 2015 that installed 15,15 GW. Undoubtedly, this level is going to be completely surpassed by Chinese PV installations in 2016. With two countries reaching levels of installations never seen before, 2015 confirmed that the 51 GW reached that year are translated in other beaten records.

OFF-GRID MARKET DEVELOPMENT

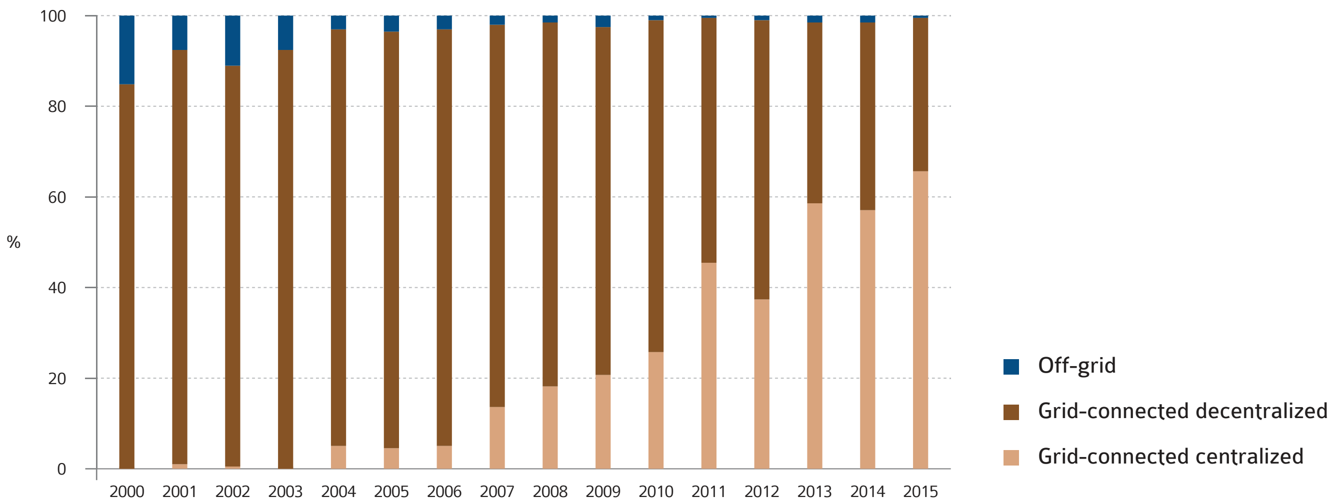
The off-grid market can hardly be compared to the grid-connected market. The rapid deployment of grid-connected PV dwarfed the off-grid market as Figure 7 clearly shows.

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

In Australia, 25 MW of off-grid systems have been installed in 2015, bringing the total to 173 MW. In China, some estimates showed that 20 MW of off-grid applications have been installed in 2015, with an unknown percentage of hybrid systems. It can be considered that most industrial applications and rural electrification systems are most probably hybrid. It must be noted that China has reached 100% of electrification in 2015, which will in any case significantly reduce the level of off-grid installations in the future. Japan has reported 2 MW of off-grid applications in 2015, bringing the installed capacity above 127 MW, mainly in the non-domestic segment.

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, for instance with around 2 MW in Sweden and 1 MW in Norway.

FIGURE 7: SHARE OF GRID-CONNECTED AND OFF-GRID INSTALLATIONS 2000-2015



SOURCE IEA PVPS & OTHERS.

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 Reunion (France) operated more than 150 MW of PV at the end of 2015 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. High PV penetration levels on several islands have direct consequences on the share of PV electricity: in Kiribati, this percentage reaches 12,3%, in Cape Verde 6,7%, and around 5% in Malta, Comoros and Solomon islands.

Outside the IEA PVPS network, Bangladesh installed an impressive amount of off-grid SHS systems in recent years. More than 4 million systems were operational by the end of 2015 with at least 180 MW installed. 6 million PV installations providing basic electricity needs for more than 30 million people are expected by end 2017.

In Latin America, Peru has committed to a program of rural electrification with PV, as is the case in many other countries.

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.

ENERGY STORAGE

2015 was a year of significant announcements with regard to electricity storage but in parallel the market is not moving quickly, except in some specific countries. The reason is rather simple: few incentives exist and the number of markets where electricity storage could be competitive is reduced. As a matter of fact, only Germany has incentives for battery storage in PV systems, Italy has a tax rebate and some cantons in Switzerland have subsidy schemes. In Germany, 35 000 systems have been installed until the end of 2015 and more are expected in 2016. Interestingly, half of the systems installed in 2015 required no financial incentive. Larger systems, up to 15 MW are expected in 2016. In the USA, 221 MW were installed in 2015, a significant increase compared to 2014 when 65 MW were installed. In the French overseas' departments (including Corsica), a call for tenders for 50 MW of PV systems above 100 kW with storage has been proposed, aiming at increasing the grid stability. In Japan, demo projects have been started on the grid as well.

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.

THE ELECTRIFICATION OF TRANSPORT, HEAT AND COLD

The energy transition will require electricity to become the main vector for applications that used to consume fossil fuels, directly or indirectly. In that respect, the development of solar heating and cooling has not experienced major developments in 2015, on the contrary to electric mobility that starts to develop in several countries. The role of PV as an enabler of that energy transition is more and more obvious and the idea of powering mobility with solar is gradually becoming a reality thanks to joint commercial offers for PV and storage. However the size of the market for electric vehicles remains significantly below the traditional one, with 540 000 units sold in 2015 or around 0,6% of the entire market. Prospects for 2016 are bright.

PV DEVELOPMENT PER REGION AND SEGMENT

FIGURE 8: SEGMENTATIONS OF PV INSTALLATION 2011 - 2015

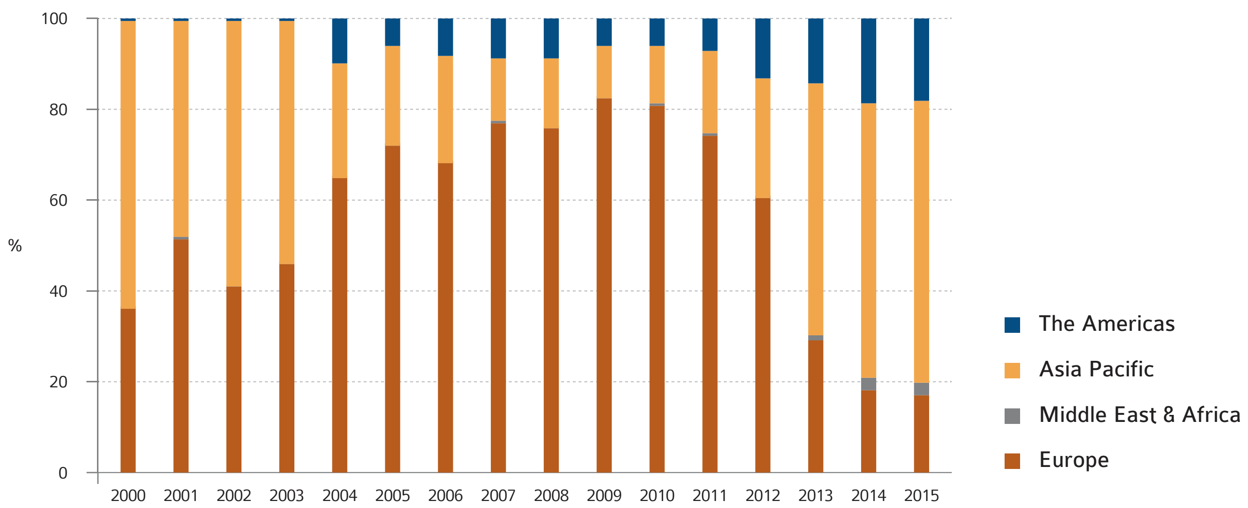
SOURCE IEA PVPS & OTHERS.

The evolution of grid-connected PV towards a balanced segmentation between centralized and decentralized PV reversed course in 2013 and continued its trend in 2015. 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 financing institutions 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, 2015 saw remarkable progress again 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 in reaching competitiveness with wholesale electricity prices in this segment, and grid connection issues, for example. However, recent developments with extremely competitive tenders below 50 USD/MWh have contributed to the increase of the utility-scale market in 2015. Globally, centralized PV represented more than 60% of the market in 2015, 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 also reinforces this evolution and reduces the development of rooftop PV even further. This becomes clearly visible with utility-scale growing in 2015 while the rooftop market stagnated or even decreased.

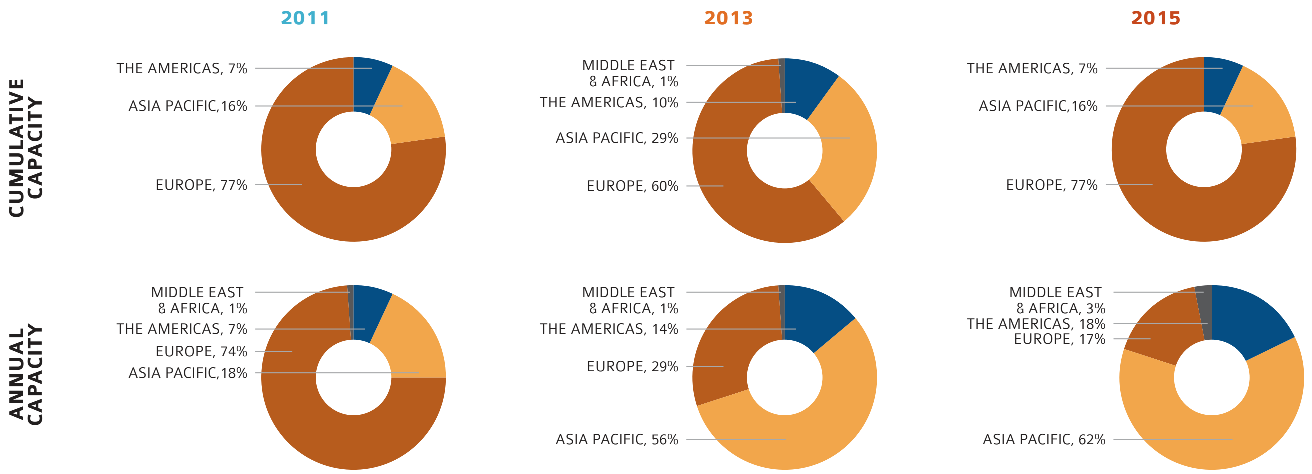
Figure 9 illustrates the evolution of the share of grid-connected PV installations per region from 2000 to 2015. While Asia started to dominate the market in the early 2000s, the start of FiT-based incentives in Europe, and particularly in Germany, caused a major market uptake in Europe. While the market size grew from around 200 MW in 2000 to above a GW in 2004, the market started to grow very fast, thanks to European markets in 2004.

FIGURE 9: SHARE OF GRID-CONNECTED PV MARKET PER REGION 2000-2015



SOURCE IEA PVPS & OTHERS.

FIGURE 10: EVOLUTION OF ANNUAL AND CUMULATIVE PV CAPACITY BY REGION 2011-2015



	CUMULATIVE CAPACITY (MW)					ANNUAL CAPACITY (MW)				
REGION	2011	2012	2013	2014	2015	2011	2012	2013	2014	2015
THE AMERICAS	4 575	8 277	13 566	20 960	29 906	2 225	3 702	5 289	7 394	8 946
ASIA PACIFIC	11 177	18 725	39 819	63 598	94 272	5 387	7 548	21 094	23 780	30 673
EUROPE	53 534	70 937	82 070	89 248	97 843	22 463	17 404	11 133	7 178	8 595
MIDDLE EAST & AFRICA	220	293	777	1 911	3 355	133	72	484	1 134	1 445
REST OF THE WORLD	371	633	917	1 363	2 360	145	262	284	447	996

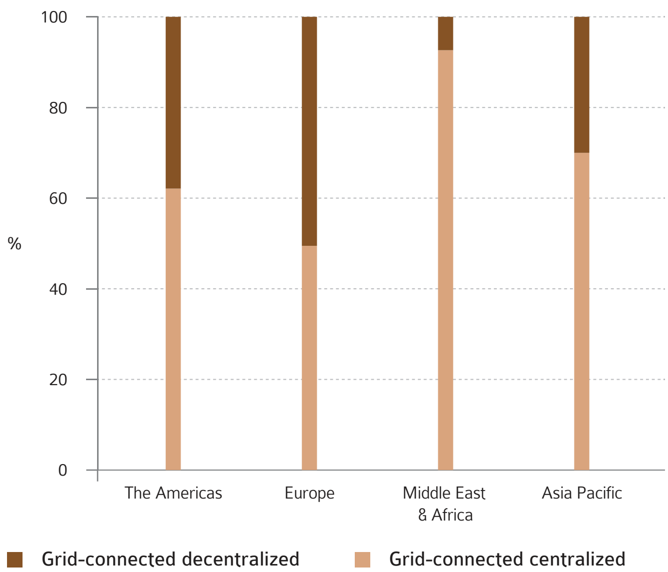
SOURCE IEA PVPS & OTHERS.

From around 1 GW in 2004, the market reached close to 2 GW in 2007. In 2008, Spain fuelled market development while Europe achieved more than 80% of the global market: a performance repeated until 2010.

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 2015, with the share of the Asia-Pacific region growing from 18% to 62%, whereas the European share of the PV market went down from 74% to 17% in five years. This trend shows that the global development of PV is not in the hands of European countries anymore.

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 market's growth in South Africa and the numerous projects in UAE, Jordan, Turkey, Algeria or Egypt.

FIGURE 11: SHARE OF GRID-CONNECTED CENTRALIZED & DECENTRALIZED PV INSTALLATIONS BY REGION IN 2015



SOURCE IEA PVPS & OTHERS.

THE AMERICAS

The Americas represented 8,9 GW of installations and a total cumulative capacity of 29,9 GW in 2015. Most of these capacities are located in the USA, and in general in North America, several countries have started to install PV in the central and southern parts of the continent; especially in Chile and Honduras in 2015 and many other markets such as Mexico are promising.

CANADA

FINAL ELECTRICITY CONSUMPTION 2015	557	TWh
HABITANTS 2015	36	MILLION
AVERAGE PV YIELD	1 150	kWh/kW
PV INSTALLATIONS IN 2015	675	MW
PV CUMULATIVE INSTALLED CAPACITY 2015	2 579	MW
PV PENETRATION	0,5	%

At the end of 2015, the installed capacity of PV systems in Canada reached more than 2,5 GW, out of which 675 MW were installed in 2015, a new increase of around 40 MW in comparison with 2014 installation level. Decentralized rooftop applications amounted to 195 MW compared to 268 MW one year earlier. Large-scale centralized PV systems continued to dominate the market, they increased from 365 MW in 2014 (slightly down from 390 MW in 2013) to 480 MW. 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. Alberta reached the second position with 9,2 MW.

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 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 has evolved to include a tendering process. Eligible PV systems are granted a FiT or microFiT contract for a period of 20 years. In 2015, 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.

In the other provinces and territories, Alberta has announced a target of electricity generated from renewable sources of 30% in 2030. In 2016, the province will introduce an auction-based approach for procurement of large-scale renewables and renewable regulatory frameworks for self-consumption and community-scale generation. Saskatchewan also announced a new target of 50% of its electricity generation coming from renewable sources. The province also committed to procuring its first utility scale solar facilities by RFP in 2016 and is conducting a regulatory review for self-consumption and small-scale generation.

The Yukon Territory initiated a successful micro-generation production incentive program offering a tariff of 0,21 CAD for grid connected and 0,30 CAD generation micro grids up to 5 kW on shared transformer, 25 kW on a single transformer and up to 50 kW on a case by case approved by the local utility.

The Canadian PV market is promising in 2016 with more than 400 MWAC of new contracts being awarded in Ontario, a new competitive procurement for utility-scale renewables being launched in Alberta in addition to a revised policy and regulatory framework for small-scale solar and the commencement of a 60 MWAC utility-scale procurement in Saskatchewan.

MEXICO

FINAL ELECTRICITY CONSUMPTION 2015	261	TWh
HABITANTS 2015	127	MILLION
AVERAGE PV YIELD	1 780	kWh/kW
PV INSTALLATIONS IN 2015	56	MW
PV CUMULATIVE INSTALLED CAPACITY 2015	170	MW
PV PENETRATION	0,1	%

After 48 MW in 2014, 56 MW of PV systems were installed in Mexico in 2015, increasing the total capacity in the country to 170 MW. Most of the rooftop PV systems installed under the net-metering scheme. To date, the authorities have awarded generation permits for grid-connected PV totaling 7 285 GW in capacity, close to 3 GW of utility scale PV projects already permitted are at different stages of development, which could be the real starting point of PV development in Mexico. Several hundreds MW are expected to come only during 2016.

In 2015, the "Constitutional Energy Reform in Mexico" approved the new system of Clean Energy Certificates and established a mechanism for long-term auctions of clean electricity, through the Law for Energy Transition (LET). The Mexican government is determined to reach a target 6 GW of self-consumption and 35% of electricity produced from clean energy by 2024.

The auction mechanism has already granted extremely low PPAs, down to 3,6 USDcents/kWh.

Amongst the incentives for PV development, 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.

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. A net-metering scheme (called "Medición Neta") exists for PV systems below 500 kW, mainly in the residential and commercial segments. In 2013, the possibility was added for a group of neighboring consumers (for instance in a condominium) to join together to obtain a permit to produce PV electricity. This specific net-metering scheme resulted in a large part of all installations.

A virtual net-metering 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". A 15% import duty has been imposed on PV modules in Mexico's PV market.

USA

FINAL ELECTRICITY CONSUMPTION 2015	4 087	TWh
HABITANTS 2015	323	MILLION
AVERAGE PV YIELD	1 400	kWh/kW
PV INSTALLATIONS IN 2015	7 283	MW
PV CUMULATIVE INSTALLED CAPACITY 2015	25 600	MW
PV PENETRATION	0,9	%

Total PV capacity in the USA surpassed 25 GW at the end of 2015 with 7 283 MW added representing a 17% annual growth compared to 2014. Once dominated by distributed installations, the USA's market is now led by utility-scale installations, representing 54% of the annual installed capacity in 2015.

In 2015, the US Environmental Protection Agency (EPA) issued final rules for carbon emissions reductions of 30% (from 2005 levels) by a state-by-state approach to be implemented between 2020 – 2030. Additionally, EPA expanded their draft rules to include a Clean Energy Incentive Programme to encourage states to meet carbon reduction goals through wind, solar and energy efficiency, providing substantial incentives to accelerate the deployment of solar and wind technologies in short term.

The USA's PV market has been mainly driven by the Investment Tax Credit (ITC) and an accelerated 5-year tax depreciation. The ITC was set initially to expire in 2016, it was recently extended to 2020. Beginning in 2020, the credits will step down gradually until they reach 10% in 2022 for commercial entities and expire for individuals. An expected market boom caused by the ITC cliff did not happen but a part of the expected installations will take place in the coming years in any case.

As of October 2015, 22 states and Washington DC had RPS policies with specific solar or customer-sited provisions. In 2015, 42 states had laws crediting customers for exported electricity, typically through a "net-metering" arrangement. In the reality these "net-metering" schemes are diverse and cover different realities between pure self-consumption and real net-metering.

Net-metering is the most popular process for selling distributed solar energy to the grid and 41 states plus the District of Columbia and Puerto Rico have net-metering policies. 18 states modified their net-metering policies in 2015. While most of these were minor rule or process changes, 3 states increased their NEM caps, 3 states transitioned to a new compensation program, and two states implemented new self-consumption policies.

3 states currently have FiTs that are accepting new applicants. Some utilities offer feed in tariffs. 15 states are offering capital subsidy, 29 states have set up an RPS (Renewable Portfolio Standard) system out of which 21 have specific PV requirements.

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 California Solar Initiative being financed in such a way. Third parties are also widely used to monetize the Investment Tax Credit in cases of insufficient tax appetite. 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.

Interestingly, due to the continued reduction in system pricing as well as the availability of new loan products and third-party arrangement with lower financing costs, a significant portion of PV systems have recently been installed without any state incentives.

In 2015, loans have emerged as an effective financial mechanism for residential systems and are even beginning to rival third-party ownership in some markets.

With regard to utility-scale PV projects, these are developing under Power Purchase Agreements (PPAs) with utilities. The support of the ITC allows to produce PV electricity at a competitive price, which allows utilities to grant PPAs.

PACE programmes have been enabled 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. 28 states currently have 50 MW or more PV capacity and 17 states each installed more than 50 MW in 2015 alone. With more than 18 GW of contracted utility scale PV projects in the pipeline as of October, total installations in 2016 are expected to increase yet again.

In December 2012, in an effort to settle claims by US manufacturers that Chinese manufacturers "dumped" products 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 ranges between 23-34% of the price of the product. In December 2013, new antidumping and countervailing petitions were filed 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

THE AMERICAS / CONTINUED

photovoltaic products."[2] 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.

Finally, state RPS targets require a larger amount of renewable energy additions in 2016 than in previous years, encouraging more growth within the market.

OTHER COUNTRIES

Several countries in Central and South America have continued developing in 2015. In Chile, 446 MW have been installed in 2015 and more are planned for 2016. 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, with a mix of PPAs with large industries and sales on the electricity market. A legislation on net-metering is Brazil, by far the largest country on the continent, has started to include PV in auctions for new power plants which led to bids at 78 USD/MWh in 2015. In addition, Brazil has now a net-metering system in place but with limited results so far. The government has set up a 3,5 GW target for PV in 2023. With 3 GW of utility-scale PV awarded through auctions to be built before 2018, and 4,5 GW of net-metered installations before 2024, Brazil's PV potential might develop very fast in the coming years. However, few MW were installed in 2015. Already announced projects to be built in 2016 represent several hundreds of MW that will contribute to market numbers in 2016 or at latest 2017. Tax exemptions exist in several states, and solar equipment have been excluded from import duties.

In Argentina, the Government has set a renewable energy target of 3 GW for 2016. This includes 300 MW for solar PV systems. However, the development has been quite small, with only a few MW installed in the country in 2015.

In Peru, 100 MW of utility-scale plants have been installed in recent years. Several programmes related to rural electrification have also been started. The tenders launched in 2015 led to 185 MW granted to developers with a rather low PPA at 48 USD/MWh at the beginning of 2016.

The PV market in Honduras has experienced a boom during 2015 with 391 MW installed. The country is expected to see more PV plants connected to the grid in 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 or Guatemala have installed several dozens of MW in 2015 through call for tenders. Several other countries including islands in the Caribbean are moving fast towards PV deployment, which could indicate to the time has come for PV in the Americas.

footnote 2 "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 30,7 GW in 2015 and more than 94,2 GW are producing PV electricity. This region again experienced a booming year with 30% as the region annual growth rate.

AUSTRALIA

FINAL ELECTRICITY CONSUMPTION 2015	248	TWh
HABITANTS 2015	24	MILLION
AVERAGE PV YIELD	1 400	kWh/kW
PV INSTALLATIONS IN 2015	1 022	MW
PV CUMULATIVE INSTALLED CAPACITY 2015	5 109	MW
PV PENETRATION	2,9	%

After having installed 1 038 MW in 2012, 811 MW in 2013, and 862 MW in 2014, Australia continued in 2015 with 1 022 MW installed. The country has more than 5,1 GW of PV systems installed and commissioned, mainly in the residential rooftops segment (more than 1,5 million buildings now have a PV system; an average penetration of 19% in the residential sector, with peaks up to 50%), with grid-connected applications.

Even though the Australian market grew in 2015, this was solely thanks to three projects under the Solar Flagships programme that were commissioned – solar farms at Nyngan 134 MW, Broken Hill 64 MW and Moree 70 MW. Utility-scale experienced a growth of over 287 MW installed whereas distributed applications have decreased 12% to 709 MW in 2015 compared with 801 MW in 2014. New domestic off-grid applications amounted in 2015 to 16 MW in the domestic sector (compared to 12,9 MW in 2014) and 9,2 MW for non-domestic applications. In total Australia counts 173 MW of off-grid systems. PV contributed to 2,8 % of the total electricity consumption in 2015 and will be able to cover at least 2,9 % in 2016 based on the already installed capacity.

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) and the Small-scale Renewable Energy Scheme (SRES). In 2015, due to a projected reduction in electricity demand, the government decided to reduce the annual generation target under LRET from initial of 41 000 GWh to 33 000 GWh by 2030. 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.

Large-scale PV benefited from several programs: an auction (ACT programme) was set up in January 2012 for up to 40 MW.

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.

In 2015, only the city of Adelaide offered storage incentive up to 50% of battery cost while in 2016, a high subsidized PV storage system will be offered by the South Australian electricity network operation in a trial.

The interest in on-site storage technologies has continued to increase with at least 472 installations of grid-connected batteries on new PV systems in 2015. The average size of grid-connected batteries was 9,4 kWh.

CHINA

FINAL ELECTRICITY CONSUMPTION 2015	5 550	TWh
HABITANTS 2015	1 371	MILLION
AVERAGE PV YIELD	1 300	kWh/kW
PV INSTALLATIONS IN 2015	15 150	MW
PV CUMULATIVE INSTALLED CAPACITY 2015	43 530	MW
PV PENETRATION	1,0	%

With 15,2 GW installed in 2015, the Chinese PV market has once again experienced a significant growth rate – approximated 43% compared to 2014. China has achieved its initial official target of 15 GW set by the National Action Planning document in the beginning of 2015. With these installations, Chinese PV capacity surpassed Germany and has become the number one country for PV installations globally, with close to 43,5 GW at the end of 2015. And much more to come.

The utility-scale segment continued to dominate the Chinese PV market with 13,7 GW installed in 2015 (out of 15,2 GW). In 2013, this segment contributed for 10,6 GW and 8,6 GW in 2014. Following the political willingness to develop the rooftop PV segment, some interest has been received and development begins in both BAPV (PV on rooftops) and BIPV (PV integrated in the building envelope) segments. In 2013, 311 MW were installed, a number that increased to 2,1 GW in 2014 and went down to 1,4 GW in 2015, showing the challenge of developing the distributed market. On the other side, the growth of centralized PV applications in the last 3 years have proven 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-grid and off-grid applications in the last un-electrified areas of the country. The following regulations were in place in 2015:

- In December 2015, the National Energy Administration set the targets of 150 GW for PV installations, translated into 170 TWh of energy by the year 2020. In this "Solar Power Application Plan during the Thirteenth Five-year Plan", utility-scale PV plants account for 80 GW and distributed PV for 70 GW, a level that might be difficult to reach. For 2016, China aims to reach installations at 18,1 GW, a number that was reached in only two quarters.
- The National Energy Administration also set the target to increase the share of PV with regard to all new power production capacities to 15%, and to reach 7% of all installed capacities.
- 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. Hence, in 2015, the National Development and Reform Commission lowered the PV feed-in benchmark price. Depending on the region, the price dropped in a range of 0,02 to 0,1 RMB/kWh to the FiT range between 0,80 and 0,98 RMB/kWh.
- In June 2015, the NEA, MIIT and CNCA jointly issued the "Opinions on Promoting Application of PV Products with Advanced Technologies and Industrial Upgrading", proposing the implementation of the "pacemaker program", which included construction of PV power pilot bases with advanced technology and new technology pilot projects, requiring that all these projects apply products with advanced technologies.
- Other special supporting programmes for PV from the Chinese government comprise the Micro-grid pilot project (to establish 30-50 micro grid demonstration project in the next 3 to 5 years) and the PV poverty alleviation program.
- A policy guidance to establish a competitive bidding for PV electricity production has been published together with NEA's "Thirteenth Five-year Plan".

In December 2015, in order to ensure a faster development of distributed PV, the National Development and Reform Commission issued the "Notice on Perfection of Onshore Wind Power and PV Power Feed-in Benchmark Price Policy". This intends to allow distributed PV system owners to choose between a self-consumption model and a pure feed-in model, with limited possibilities to switch the remuneration model during the plant lifetime.

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

China was the first PV market in the world for the third year in a row in 2015. 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 20 to 25 GW of PV systems every year. Due to the fact that incentives for utility-scale PV plants were expected to be lowered mid 2016, the first half year of 2016 witnessed a rapid increase in the construction of utility-scale PV plants. According to statistics of the NEA, in the half year alone, the newly added PV capacity already reached 20 GW, reaching already the annual target. PV contributed to 0,71% of the total electricity consumption in 2015 and will be able to cover at least 1,0% in 2016.

JAPAN

FINAL ELECTRICITY CONSUMPTION 2015	953	TWh
HABITANTS 2015	127	MILLION
AVERAGE PV YIELD	1 050	kWh/kW
PV INSTALLATIONS IN 2015	10 811	MW
PV CUMULATIVE INSTALLED CAPACITY 2015	34 150	MW
PV PENETRATION	3,8	%

The PV installed capacity reached 10,8 GW (DC) in Japan in 2015, a 11% increase compared to the year 2014. The total cumulative installed capacity of PV systems in Japan reached 34,2 GW in 2015, making it the third largest country in terms of PV cumulative installed capacity. 2,4 MW of off-grid systems were installed, bringing the total off-grid capacity in Japan to 127 MW.

With the start of the FiT programme in July 2012, the market for public, industrial application and utility-scale PV systems grew fast and brought rapidly Japan to the top of the global PV market. While Japan was one of the first market in the world in the first decade of this century, most installations took place after the implementation of the FiT program.

While the PV market in Japan developed in the traditional residential rooftop market, 2015 has seen again a major deployment of utility-scale plants: such systems grew from 3,2 GW in 2014 to 4,4 GW in 2015. Very-large scale PV systems directly connected to the transmission grid represented 2,8 GW out of 34 GW at the end of 2015.

Feed-in Tariff

The FiT scheme remains the main driver for PV development in Japan. On 1st July 2012, the existing scheme that allowed purchasing excess PV production was replaced by this new FiT scheme, paid during 20 years for systems above 10 kW and 10 years for the excess electricity of PV systems below 10 kW. Its cost is shared among electricity consumers with some exceptions for electricity-intensive industries. This scheme, considered sometimes as quite generous, has triggered the important development of the Japanese PV seen in last three years.

In July 2015, the FiT was adjusted downwards by about 16% with little impact on the PV market so far. However, the rapid price decline for PV modules indicates that the margins of installers and developers are also declining. Capital subsidies are also available for system not applying to the FiT, for commercial, industrial and utility-scale applications. A system of green certificates also exists for utility-scale plants but since it provides a lower remuneration than the FiT, it is not widely used for PV systems.

Self-Consumption

For prosumers' PV systems below 10 kW, the FiT programme is used to remunerate excess PV electricity. The self-consumed part of PV electricity is not incentivized. Self-consumed electricity is not subject to taxation and transmission & distribution charge. Self-consumption can benefit from subsidies in the commercial segment.

BIPV

BIPV has been included in demonstration programs that are currently running. The market for BIPV remains relatively small compared to the usual BAPV market and 60 MW were installed in 2015. However, Japan is preparing the offtake of BIPV. NEDO started a study project named "study on BIPV" in order to collect information and identify issues for the commercialization of BIPV systems in 2016. In addition, METI started a project on "International standardization of BIPV modules" in 2015.

Storage

New demonstration projects to install storage batteries were started in various locations in 2015. They aim at managing the rapidly increasing penetration of PV. The "Demonstration Project for Improving the Balance of Power Supply and Demand with a Large-Capacity Storage Battery System" installs large-capacity storage batteries at grid substations in order to reduce reverse flows and better manage the impact of concentrated PV installations. Decentralized storage in residential PV applications is incentivized in order to increase the reliability of the power provision in case of emergency. Demonstration projects are also conducted for hydrogen storage.

Conclusion

The second market for PV reached a high level in 2015 with 10,8 GW and will most probably experience a decline and hopefully a soft landing in the coming years. The appetite for electricity after the Great Earthquake in 2011 and the need for diversifying the electricity mix is expected to start its PV development. Given the geographical configuration of the archipelago, it is highly probable that decentralized PV applications will constitute the majority of PV installations in some years. With numerous global PV players in all segments of the value chain, Japan will be one of the key players in tomorrow's energy world. PV contributed to 3,5 % of the total electricity consumption in 2015 and will be able to cover at least 3,8 % in 2016 based on the already installed capacity.

KOREA

FINAL ELECTRICITY CONSUMPTION 2015	484	TWh
HABITANTS 2015	51	MILLION
AVERAGE PV YIELD	1 314	kWh/kW
PV INSTALLATIONS IN 2015	1 011	MW
PV CUMULATIVE INSTALLED CAPACITY 2015	3 493	MW
PV PENETRATION	0,9	%

Since "The Renewable Portfolio Standards" (RPS) replaced the Korean FiT at the end of 2011, the Korean PV market followed an upward trend. In 2015, under this programme, the Korean PV market passed the GW mark with 1 011 MW compared to 926 MW in 2014.

At the end of 2015, the total installed capacity reached 3,5 GW, among which utility-scale PV plants accounted for around 88% of the total cumulative installed capacity. Distributed PV systems amounted to around 12% of the total cumulative capacity. The share of off-grid PV systems has continued to decrease and represents less than 1% of the total cumulative installed PV capacity. PV contributed to 0,74 % of the total electricity consumption in 2015 and will be able to cover at least 0,9 % in 2016.

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 18 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 2015 alone, 924 MW were installed under this programme. With regard to the cumulative installed capacity, about 68% of the total PV installations in Korea were made under the RPS scheme, to be compared with about 500 MW (about 14%) that were installed under the previous 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 2015, 21 MW were installed under this programme.

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. Various grid-connected PV systems were installed in schools, public facilities, welfare facilities, as well as universities. In 2015, 6 MW was installed under this programme.

Regional Deployment Subsidy Programme

The government supports 50% of the installation cost for NRE (including PV) systems owned or operated by local authorities. In 2015, 14 MW was installed under this programme.

Public Building Obligation Programme

The new buildings of public institutions, the floor area of which exceeds 1 000 square meters, are obliged by law to use more than 15% (in 2015) 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. In 2015, 33 MW was installed under this programme.

PV Rental Programme

Household owners who are using more than 350 kWh electricity can apply for this program. Owners pay a 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 fees and selling the REP (Renewable Energy Point) having no multiplier. In 2015, 8,6 MW (8 796 households) were installed under this programme.

Convergence and Integration Subsidy Programme for NRE

This programme is designed to help diffuse the NRE into socially disadvantaged and vulnerable regions and classes such as islands, remote areas (not connected to the grid), long-term rental housing district, etc. Local adaptability is one of the most important criteria, thus the convergence between various NRE resources (PV, wind, electricity and heat) and the complex between areas (home, business and public) are primarily considered to benefit from this programme. In 2015, 5 MW was installed under this programme.

MALAYSIA

FINAL ELECTRICITY CONSUMPTION 2015	128	TWh
HABITANTS 2015	30	MILLION
AVERAGE PV YIELD	1 200	kWh/kW
PV INSTALLATIONS IN 2015	27	MW
PV CUMULATIVE INSTALLED CAPACITY 2015	230	MW
PV PENETRATION	0,2	%

The PV market declined in 2015 to 26,8 MW while 65 MW were installed in 2014, and 107 MW in 2013. The total installed capacity in Malaysia now tops 230 MW. As of the end of December 2015, the Authority approved a total of 7 271 new applications (equivalent to 324,81 MW).

ASIA PACIFIC / CONTINUED

The market was mostly dominated by rooftop applications, with 18,7 MW of BAPV in all segments and 6,07 MW of BIPV installations. ground-mounted applications represented 2 MW in 2015.

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 imposed on 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. On 29 December 2015, new degression rates were announced. The degression rates for installed PV capacities of up to 1 MW remained unchanged whereas for PV systems with capacities greater than 1 MW and up to 30 MW, the rate was revised from 20% to 15%.

In October 2015, the Prime Minister of Malaysia announced a net-metering scheme with a 100 MW quota per year for PV installation starting 1st November 2016, that could accelerate the development of the PV market in Malaysia. Finally, BIPV installations are incentivized with an additional premium on top of the FiT, which allowed 6,07 MW of installations in 2015.

THAILAND

FINAL ELECTRICITY CONSUMPTION 2015	175	TWh
HABITANTS 2015	66	MILLION
AVERAGE PV YIELD	1 226	kWh/kW
PV INSTALLATIONS IN 2015	121	MW
PV CUMULATIVE INSTALLED CAPACITY 2015	1 420	MW
PV PENETRATION	1,0	%

In Thailand, at the end of 2015, the cumulative grid-connected PV capacity reached 1,42 GW, with around 30 MW of off-grid applications. The PV market declined significantly in Thailand with only 121 MW that have been installed in 2015 compared to 475 MW in 2014 and 437 MW in 2013. Almost all installations realized in 2015 were utility-scale ones, while less than 1 MW of new off-grid systems were deployed. According to the latest Alternative Energy Development Plan 2015-2036, Thailand aims to reach 6 GW of total installed PV capacity in the next 20 years.

In the past, PV developed slowly in Thailand mainly for off-grid applications in rural areas. Since 2010, the PV market took off rapidly thanks to the new FiT scheme and several GW of PV plants were applied and often realized.

Thailand uses a FiT scheme to incentivize PV plants. FiT is financed through a levy on the electricity bills (FT rate) for all electricity consumers and is valid for 25 years. Moreover, a PV rooftop pilot project (self-consumption) will be tested in 2016 with the objective to study and monitor the impact of self-consumption on the utilities, the electricity systems and the investors. The result of the pilot project will be used as a recommendation for the real implementation of self-consumption or a net-metering scheme in the future.

Three programs were active in 2015:

- The 2nd phase of the rooftop program for residential installation (less than 10 kWp) which has been first introduced in 2014. Total target for both phases was set at 100 MWp.
- The Governmental Agency and Agricultural Cooperatives Program: The target was set for 800 MWp. The project will benefit new FiT rates that have been published in 2015: this FiT pays 5,66 THB/kWh for utility-scale systems below 5 MW. This scheme was divided in two phases, 600 MW followed by 200 MW in 2016.
- The PV ground-mounted power plant program under 90 MW, applied for application submitted under the old Adder scheme and halted in 2010. Such projects are granted with the FiT rate of 5,66 THB/kWh for 25 years instead of the former Adder scheme.

PV for rural electrification can be subsidized up to 100%, for schools, community centers, national parks, military installations or hospitals. However the capacities installed remain very low, with some kWp in each case.

PV investors are offered exemption in corporate tax and import duty for machinery if the capital investment is above a certain level and also have a program to support the deployment of PV as energy efficiency solution which will help factory/building to reduce their electricity bills required by Board of investment (BOI).

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

OTHER COUNTRIES

2015 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 jumped to 2,1 GW in 2015 from 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 systems 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. The support of the central government in India for PV is now obvious and will lead in the coming years to a significant increase of installations.

In 2015 Taiwan installed about 227 MW mostly as grid-connected rooftop installations. The total installed capacity at the end of 2015 is estimated to be around 842 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 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" aimed 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 has shown for 2014.

The Government of Bangladesh has been emphasizing the development of solar home systems (SHS), since about half of the population has no access to electricity. Under the Bangladesh zero-interest loan from the World Bank Group as well as support from a range of other donors, the government is promoting incentive schemes to encourage entrepreneurs who wish to start PV actions; at present 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 deployment exploded in recent years. The number of systems in operation is estimated above 4 million SHS in the beginning of 2016. More are expected after some financing from the World Bank, up to 6 million by the end of 2017. 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 of 1 500 irrigation PV pumps by 2018. The government started to introduce more PV power by setting up 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 installed several hundreds of MW which followed the approval of 793 MW of solar plants. A FiT has been introduced for utility-scale PV in 2014. A power plant of 1 GW is being built and 100 MW have been commissioned already in 2015. Brunei has announced that a FiT policy should be put in place over the next 18-24 months. The Philippines have installed 110 MW in 2015, raising the total installed capacity to 144 MW and much more is foreseen in the coming years. As of 31st December 2015, there were 124 grid-connected projects in the pipeline that had been awarded under the country's renewable energy (RE) law, totalling 4 016MW. Meanwhile, there were 13 self-consumption projects totalling 2,4 MW also awarded. Total self-consumption capacity stood at 1,9 MW at the end of 2015.

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. However, so far only 20 MW were installed in 2014 and in 2015 the first utility-scale plants were connected to the grid. In early 2016 the government announced a 5 GW plan to develop PV in the country.

Myanmar has signed a memorandum for building several large-scale plants and 220 MW were foreseen at the end of 2015. In Singapore, the total PV installed capacity was 30 MW at the end of 2015 with a target of 350 MW in 2020. Uzbekistan has the intention to install 2 GW of PV plants and 300 MW of utility-scale plants were being developed at the end of 2015. In Kazakhstan, 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 and represented more than 70% of the global cumulative PV market until 2012. Since 2013, European PV installations went down while there has been rapid growth in the rest of the world. Europe accounted for only 17% of the global PV market with 8,5 GW in 2015. European countries installed 98 GW of cumulative PV capacity by the end of 2015, still the largest capacity globally, for the last year. It is important to distinguish the European Union and its countries, which benefit from a common regulatory framework from part of the energy market, and other European countries which have their own energy regulations.

AUSTRIA

FINAL ELECTRICITY CONSUMPTION 2015	60	TWh
HABITANTS 2015	9	MILLION
AVERAGE PV YIELD	1 027	kWh/kW
PV INSTALLATIONS IN 2015	152	MW
PV CUMULATIVE INSTALLED CAPACITY 2015	937	MW
PV PENETRATION	1,6	%

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 2012. With 363 MW in 2013, 159 MW in 2014 and 152 MW in 2015, the market appears to enter a stage of stable growth. Off-grid development amounted to only 5,5 MW out of 937 MW as Austria cumulative market end of 2015.

Systems below 5 kWp are incentivized through a financial incentive. Additional investment subsidy is available 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, some provinces are providing additional incentives through investment subsidies.

Self-consumption is allowed for all systems. Self-consumption fees of 1,5 EURcent/kWh have to be paid if the self-consumption is higher than 25 000 kWh per year.

Rural electrification in remote areas not connected to the grid is incentivized through an investment subsidy up to 35% of the cost. Since 2015, more and more provinces provide investment grant to support the installation of decentralized electricity storage systems in combination with PV. For example, Vienna provides a limited incentive of 500 EUR/kWh while Burgenland has a non-refundable rebate of 275 EUR/kWh for storages up to 5 kWh. 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 2015	82	TWh
HABITANTS 2015	11	MILLION
AVERAGE PV YIELD	990	kWh/kW
PV INSTALLATIONS IN 2015	97	MW
PV CUMULATIVE INSTALLED CAPACITY 2015	3 250	MW
PV PENETRATION	3,9	%

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 organization, 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.

Flanders started to develop first and installed more than 2,35 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 850 MW at the end of 2015. In Flanders, large rooftops and commercial applications have developed since 2009. 97 MW were installed in the country in 2015, a slight increase in comparison with 94 MW installed in 2014. Belgium now runs 3,25 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 in 2012, with 291 MW installed solely in the residential segment of the 3 million inhabitants of the region. 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 were cancelled in November 2011.

In Flanders, the prosumer fee was introduced in July 2015 for all small PV systems (below 10 kW). Larger systems have no net-metering or prosumer fee. They benefit from a self-consumption scheme and from an additional green certificate GC support scheme. In 2015, for large systems in Wallonia, the GC reservation controls the market deployment by linking the GC amount per kWh with the system size. This change drove down the level of installations in the Wallonia region to only 29 MW in 2015. Brussels will be the first region to replace the yearly net-metering system for small systems (< 5 kW) by a self-consumption scheme by 2018. The Green Certificates support has been increased in the beginning of 2016.

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 2015	31	TWh
HABITANTS 2015	6	MILLION
AVERAGE PV YIELD	950	kWh/kW
PV INSTALLATIONS IN 2015	181	MW
PV CUMULATIVE INSTALLED CAPACITY 2015	787	MW
PV PENETRATION	2,4	%

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

That 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 to 42 MW in 2014. The PV market then increased significantly in 2015 with 181 MW installed, thanks mainly to utility-scale applications which represented 131 MW, and a rather stable rooftop market. Off-grid remains anecdotic with 0,4 MW installed.

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 from 2013 onwards. 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. Since then, the PV market 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 FiT system was suspended in May 2016 due to its success. The net-metering system has now a cap of 800 MW (+20 MW for municipal buildings) until 2020.

At the end of 2015, Denmark launched a one-off pilot tender scheme of 20 MW for utility-scale ground-mounted PV systems up to 2,3 MW. A particularity from that tendering system is that it is open to German bids, which implies that PV installations in Germany could compete in the tender and the other way around. The utility-scale development that has been seen in 2015 was the consequence of an interpretation of the existing legislation: Five utility-scale PV farms ranging from 9 to 70 MW were registered in December 2015. All were built in sub-units of 400 kW driven by the 2015 FiT regulations.

There are presently no direct support measures for BIPV. However, the building codes promote the use of BIPV in new buildings and at major refurbishments.

Finally, the debate about the legality of the scheme supporting PV in Denmark has been questioned by European authorities, under the excuse that they could oppose state aid regulation, which was pushing the Danish government at that time to move the budget to support PV to the state budget. This example shows how pro-PV regulations could become a complex regulatory issue in today's Europe, with the need to choose between the energy transition and free-market regulations.

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 the European level. Directive 2009/28/EC set mandatory targets for the Member States, but let them decide about the way to achieve their binding 2020 targets, PV targets were set up in various ways. In October 2014, the European Council adopted an EU targets until 2030 for renewable energy development in the framework of its climate change policies. It set a new target of at least 27% of renewable energy sources in the energy mix, together with energy savings targets and GHG emissions. However, different to the 2009 Directive no mandatory targets have been proposed for the individual Member States and it is unlikely that the new directive under preparation will do so.

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 the last years 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. In parallel to this, it is important to mention the failure of the Emission Trading Scheme (ETS), that aimed at putting a carbon price which would have normally pushed coal power plants out of the market. However due to the inability of the scheme to maintain a fair carbon price,

EUROPE / CONTINUED

coal power plants were not decommissioned. More than 100 GW of gas power plants that were built in the last decade in anticipation of the decommissioning of coal power plants finally caused a huge overcapacity in conventional electricity production. In that respect, with more than a decade of rapid increase of production capacities and electricity consumption stagnation, several utilities suffer from reduced operating hours and lower revenues. 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 Member States as well as companies 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 continued in 2015 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 European Commission adopted final measures in the solar trade case with China in December 2013 which were still applicable at the end of 2015.

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, were not applied 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. Following the decline of PV modules costs and prices, some companies decided to go out of the agreement and to enter the European PV market by paying the anti-dumping charges: the low prices on the market should continue to push additional companies to exit the agreement.

The Energy Performance in Buildings Directive (EPBD) will enter into force in 2020 and might become an important driver of PV development in the building sector by pushing PV as the main possibility to reduce the net energy consumption in buildings after energy efficiency. While the final effect will have to be scrutinized after 2020, it represents a major opportunity for the building sector and PV to work together.

FINLAND

FINAL ELECTRICITY CONSUMPTION 2015	83	TWh
HABITANTS 2015	6	MILLION
AVERAGE PV YIELD	838	kWh/kW
PV INSTALLATIONS IN 2015	5	MW
PV CUMULATIVE INSTALLED CAPACITY 2015	13	MW
PV PENETRATION	0,0	%

The total capacity of grid-connected PV plants is estimated at around 13 MW. However, the market in 2015 witnessed visible signs that the segment of grid-connected rooftop PV systems is starting to grow in commercial and residential scales with 5 MW installed. There has been no utility-scale PV plants in Finland so far. The off-grid PV market in Finland started in the 80s 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. At the beginning of 2016, the subsidy level decreased to the level of 25%. 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 and is about to rise to 40% in 2016. 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, the current net-metering scheme is real-time, and the majority of installed electricity meters do not net-meter between phases. The hourly-based net-metering for individual consumers is under active discussion, and will possibly be implemented. In residential and commercial scales 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 an 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 2015	476	TWh
HABITANTS 2015	67	MILLION
AVERAGE PV YIELD	1 150	kWh/kW
PV INSTALLATIONS IN 2015	887	MW
PV CUMULATIVE INSTALLED CAPACITY 2015	6 589	MW
PV PENETRATION	1,6	%

The French market that used to be among the least developing in Europe some years ago is now one of the highest on the continent. The political decision was made to maintain the market around 1 GW per year in the last years and to increase it in the coming years. The newly added capacity in France decreased slightly to 887 MW in 2015 compared with 954 MW in 2014, after having reached 1 120 MW in 2012 and 654 MW in 2013; a number that could increase in the coming years. After COP21, France has put an effort into boosting its solar market by revising the national PV installation target to 10,2 GW in 2018 and between 18 to 20 GW in 2023.

The rooftop market below 250 kW represented around 33% whereas systems above 250 kW, both rooftop and utility-scale, around 67% of added capacity in 2015. The total installed capacity reached 6,56 GW end of 2015, including overseas departments. In total utility-scale PV systems represented 2,3 GW at the end of 2015, with a 300 MW plant installed in 2015. Off-grid installations in 2015 were around 0,4 MW while the total off-grid installed capacity is close to 30 MW.

The national support measures currently implemented in France are guaranteed feed-in-tariffs (paid by electricity consumers) and tendering processes for systems above 100 kW. One specific of the French regulatory framework lies in the priority given to supporting BIPV systems over conventional BAPV systems. Systems up to 100 kW with simplified building integration enjoy a 10% increase of the FiT compared to the previous version. For systems larger than 100 kW, the FiT has decreased significantly to support the development of competitive projects. Alternatively, projects starting at 100 kW can apply to calls for tenders. A new calendar for new tenders with capacity of 4 350 MW between 2016 and 2019 was published in 2015.

So far, the low retail prices for electricity have been a challenge for the development of self-consumption in France. Hence, some regions are promoting self-consumption projects through their calls for proposals. New call for tenders will be dedicated to self-consumption from 2016.

The income tax credit for private BIPV roof owners was phased out on 1 January 2014, but the material costs still benefit from a reduced 10 % VAT rate.

In 2016, the residential hybrid system PV-T will be eligible to the CITE energy transition tax credit. Additionally, from 2017, a new support mechanism for renewables over 0,5 MW will be established to create an environment where electricity generated from renewable sources will be sold directly on the electricity spot market.

The support to BIPV explains the relatively high costs of support schemes in France. Overseas departments and territories of France are mainly composed of islands with different grid connection rules than the mainland in order to cope with the smaller grids.

GERMANY

FINAL ELECTRICITY CONSUMPTION 2015	521	TWh
HABITANTS 2015	81	MILLION
AVERAGE PV YIELD	1 055	kWh/kW
PV INSTALLATIONS IN 2015	1 461	MW
PV CUMULATIVE INSTALLED CAPACITY 2015	39 710	MW
PV PENETRATION	8,0	%

With three years in a row above 7 GW of PV systems connected to the grid, Germany used to be the most iconic PV market for years . 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.

From 2013 to 2015, the PV market went down to 3,3 GW then 1,46 GW, below the political will to frame the development of PV within a 2,4-2,6 GW range each year. This results into a total installed PV capacity of 39,7 GW connected to the electricity grid at the end of 2015. 2015 was also the year that saw China overtaking Germany and installing itself in the very first place.

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.

With a level of PV installations in 2015 almost 1 GW below the 2,4-2,6 GW corridor, the FIT decline was stopped. This procedure that was supposed to control the growth of the market is now used in Germany to halt the severe market decline.

EUROPE / CONTINUED

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 paid by prosumers for the self-consumed electricity for systems above 10 kW. This part will increase up to 40% in 2017.

A programme of incentives for storage units was introduced 1st May 2013, which aims at increasing self-consumption and developing PV with battery storage in Germany. A 25 MEUR market stimulation programme has been introduced to boost the installation of local stationary storage systems in conjunction with small PV systems (< 30 kWp). Within the framework of this storage support programme around 20 000 decentralized local storage systems were funded by the end of 2015. A continuation of the programme is planned for 2016. It is interesting to mention that in addition to incentivized storage systems, additional ones were installed without incentives, around 9 000 in 2015.

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 on the market during a period of time instead of getting the fixed tariff and receiving an additional premium on the top of the market price. The producer can go back and forth between the FiT system and the market as often as necessary. New PV installations > 500 kWp (from 2016 on PV installations > 100 kWp) are obligated to direct marketing of generated electricity.

In 2015, within the "market integration model" three pilot auctions have taken place for utility-scale PV installations. The three calls covered a capacity of 500 MW altogether and were characterized by a high degree of competition. The price level was reduced from call to call: from 0,0917 EUR/kWh it declined continuously: The most recent price obtained from the fifth solar auction in August 2016 was 0,0723 EUR/kWh.

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 2015	297	TWh
HABITANTS 2015	61	MILLION
AVERAGE PV YIELD	1 326	kWh/kW
PV INSTALLATIONS IN 2015	300	MW
PV CUMULATIVE INSTALLED CAPACITY 2015	18 906	MW
PV PENETRATION	8,4	%

In 2015, Italy installed a modest 300 MW, confirming the significant slowdown already seen for years. The total installed capacity reached 18 906 MW at the end of 2015. The low market performance can be attributed to the end of the FiT era (2005-2013), that originated from the reach of the financial cap of 6,7 BEUR in terms yearly payments.

In the last 17 years, Italy developed different incentive mechanisms. The first one was the "10 000 PV roofs" that was implemented in the early 2000, followed in July 2005 by a Feed-in Tariff (Feed-in Premium until 2012) system, the so-called "Conto Energia". This scheme was regulated with four successive ministerial decrees that further exploited the already existing mechanism of net-metering and a real time self-consumption. The cost of the incentive is covered by a component of the electricity tariff structure paid by all final consumers.

Italy in 2009 switched from the net-metering mechanism to the so-called "Scambio Sul Posto" (SSP) for systems below 200 kW (500 kW for plants installed starting from 2015). The SSP is a net-billing scheme, in which electricity fed into the grid is remunerated through an "energy quota" based on electricity market prices and a "service quota" depending on grid services costs (transport, distribution, metering and other extra charges). In case the producer does not want to apply for the SSP, electricity market prices are applied for the electricity injected into the grid.

Tax credit (available only for residential plants up to 20 kW), together with the net-billing scheme, are the remaining measures to support the PV market. Out of 300 MW installed in 2015, almost all plants are under the SSP net-billing scheme.

Residential installations represented half of the PV Italian market in 2015. The market for utility-scale PV plants has significantly decreased after the end of the FiT and has not caught up since then, due to, among others, the low wholesale electricity market prices that cannot provide a significantly safe return for utility-scale PV plants.

This price decrease that is not a specific of Italy is more pronounced there for several reasons, from the weakness of the electricity demand due to economic stagnation, the fall of gas prices (gas is the main fuel in the power generation in Italy) and the abundance of electricity supply from RES, among which PV.

The introduction of the so-called "Sistema Efficiente di Utenza" (SEU), a system in which one or more power production plants operated by a single producer are connected through a private transmission line to a single end user located on the same site, did not produce a significant growth of the capacity installed.

Regarding storage, tax credit measures are foreseen, but so far storage has been installed in few residential PV plants, integrated with the inverter in order to achieve a better performance of the installed system.

NETHERLANDS

FINAL ELECTRICITY CONSUMPTION 2015	113	TWh
HABITANTS 2015	17	MILLION
AVERAGE PV YIELD	950	kWh/kW
PV INSTALLATIONS IN 2015	437	MW
PV CUMULATIVE INSTALLED CAPACITY 2015	1 560	MW
PV PENETRATION	1,3	%

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 which lasts till now. In 2015, 437 MW of PV systems were installed, pushing the PV installed capacity to the 1,5 GW mark, mostly in the residential PV market.

A reverse auctioning system exists for large-scale PV systems, called SDE+ which attracted 48 MW in 2013, 137 MW in 2014 but only 1 MW in 2015.

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.

To reach the goal of PV accounts for 15% of total renewable energy production and 7% of total electricity demand in 2030, there is potential of 1 GW of PV installations a year.

With good research centers and companies active in the PV sector, the Netherlands appears as an interesting innovator that could accelerate the emergence of BIPV in Europe. From PV roads to concept for complete roof renewals, PV integrated in the built environment (and not only in buildings) could provide an interesting framework for the future in a country where free space is scarce and the built environment majoritary. From a market point of view, the political commitment to keep the net-metering scheme until the end of the decade offers a safe harbour for PV investment, before the expected transition to a pure self-consumption regulatory regime.

NORWAY

FINAL ELECTRICITY CONSUMPTION 2015	129	TWh
HABITANTS 2015	5	MILLION
AVERAGE PV YIELD	800	kWh/kW
PV INSTALLATIONS IN 2015	2	MW
PV CUMULATIVE INSTALLED CAPACITY 2015	15	MW
PV PENETRATION	0,0	%

The PV market in Norway was driven mainly by off-grid applications until 2014. However, this was taken over by grid-connected segmentation when it jumped ten-fold from 0,1 MW in 2013 to 1,4 MW at the end of 2014. 2015 saw a decrease in commercial business installations, but this was offset with the growth coming from household systems. Therefore, the grid-connected segment increased modestly to 1,5 MW in 2015. Overall, the total installed capacity reached 15,3 MW at the end of 2015. The estimates for 2016 indicate further market growth to around 6 MW.

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). This segment is growing caused by an increasing number of larger hybrid systems with larger battery-capacities, diesel or petrol back-up generators and electrical conversion to 230 Volt AC.

From January 2015, owners of small PV systems below 15 kWp are eligible for a financial investment support provided by Enova SF, a public agency owned by the Ministry of Petroleum and Energy. Enova also offers financial supports for "Building with High-Energy Performance" where the energy performance goes beyond the normal technical norms. Environmental quality is an increasingly important market parameter for stakeholders in the Norwegian building and construction sector. Enova has a strong focus on energy efficient buildings and supports innovative technologies and solutions. BIPV and associated batteries, and smart control is emerging along with new companies with innovative business models.

In 2014, the municipality of Oslo launched a capital subsidy for PV systems on residential buildings covering a maximum of 40% of the investment cost and total budget of 2 MNOK, which was increased with 4 MNOK in 2015. So far, 120 projects are registered under this scheme. The programme has been extended to 2016 with an additional budget of 2 MNOK.

Self-consumption is allowed for residential systems provided that the customer is a net consumer of electricity on a yearly basis and limits the feed-in to maximum 100 kW. During 2015, self-consumption for large PV systems were under discussion to be eligible for el-certificate (Renewable Energy Certificates, RECS) market which created uncertainty for investors, but from 2016 PV-plants can receive el-certificates for the total annual production for 15 years. The value of the el-certificates is not fixed, but is priced in the range of 0,15 NOK/kWh at the moment.

EUROPE / CONTINUED

Power-plants must be in operation within the end of 2020 to be part of the RECS support program.

With a low density of population, a nordic climate (which fits perfectly the use of PV) and an extremely high share (96-99%) of cheap (0,20-0,50 NOK/kWh in the summer), hydro-based renewable energy in the electricity mix, Norway is not expected to become a huge PV market. However it represents an interesting showcase of PV possibilities, with political commitment, in the country where the market share of electric vehicles was the highest globally in 2015.

PORTUGAL

FINAL ELECTRICITY CONSUMPTION 2015	51	TWh
HABITANTS 2015	10	MILLION
AVERAGE PV YIELD	1 700	kWh/kW
PV INSTALLATIONS IN 2015	49	MW
PV CUMULATIVE INSTALLED CAPACITY 2015	465	MW
PV PENETRATION	1,6	%

The Portuguese PV market stood at 49 MW in 2015, illustrating a huge drop from the level of installation of 117 MW in 2014. The total installed capacity arrived at about 465 MW end of 2015. The market has been mostly driven by the FiT scheme.

By October 2014, the new self-consumption and FIT regime regulation for small units (systems under 250 kW) was published.

On January 2015, the Green Tax Reform was implemented setting the maximum tax depreciation of solar at 8%. The proposal of reducing 50% of the Municipal Real Estate Tax (IMI) for RES power producing buildings was accepted.

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 2015	263	TWh
HABITANTS 2015	47	MILLION
AVERAGE PV YIELD	1 500	kWh/kW
PV INSTALLATIONS IN 2015	54	MW
PV CUMULATIVE INSTALLED CAPACITY 2015	5 430	MW
PV PENETRATION	3,1	%

In 2007 and 2008, Spain's FiT programme triggered a rapid expansion of the PV market. After a moratorium in October 2008 that made the market go down, in January 2012 a new moratorium was put in place for all the renewables projects with FiT. In 2015, only 49 MWDC were installed in Spain and the total installed capacity tops more than 4,8 GWAC (5,4 GWDC), which can be explained by the difficult economic environment and the constraining PV policies.

Consecutive Spanish governments put in place a legal framework allowing that the revenues coming from the price of retail electricity were below total system costs, which created the tariff being paid by electricity consumers. The cumulated deficit amounts now to 15 BEUR and it is estimated that the cost of renewables paid by electricity consumers has contributed to around 20% of this amount. In order to reduce this deficit, retroactive measures have been taken to reduce the FiTs already granted to renewable energy sources but no other significant measures have been taken to reduce the deficit.

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 biggest project have changed hands, since international investors found interests in the acquisition of this projects.

The 24/2013 Power Sector Act considers very restrictive forms of self-consumption. During 2015 the regulatory framework for self-consumption was developed under Royal Decree (RD) 900/2015. This RD established that the maximum capacity of the self-consumption installation must be equal or below the contracted capacity. It also specifies two types of self-consumers:

- Type 1: maximum capacity installed of 100 kW – there is no compensation for the electricity surplus fed in the grid.
- Type 2: no limit to the allowed capacity – the surplus can be sold in the wholesale market directly or through an intermediary. A specific grid tax of 0,5 EUR/MWh has to be paid together with a 7% tax on the electricity produced.

Regulation indicates that self-generated power above 10 kW is charged with a fee per kWh consumed as a "grid backup toll", commonly known as the "sun tax". Adding battery storage to the installation also implies an additional tax.

Geographical compensation is not allowed, and self-consumption for several end customers or a community is not allowed.

The Spanish PV industry has obviously, still on the downside with taxes, applied to self-consumers and no feed-in-tariff at all. However, grid parity has been reached in Spain thanks to two factors: rich solar irradiation resource and good prices for components. Given the context of no feed-in-tariff, the future of the Spanish PV market lies in the deployment of big PV plants and the elimination of the self-consumption barriers. However, the opposition political parties and the main social stakeholders have expressed their support to a fair development of PV through self-consumption, and depending on the 2016 elections outcome in Spain, the regulation could change again. Given the need to meet the EU energy and climate 2020 targets and the Paris Agreement, It is of utmost importance that a new legislative framework is developed in Spain promoting the use of renewable energies again.

SWEDEN

FINAL ELECTRICITY CONSUMPTION 2015	145	TWh
HABITANTS 2015	10	MILLION
AVERAGE PV YIELD	950	kWh/kW
PV INSTALLATIONS IN 2015	47	MW
PV CUMULATIVE INSTALLED CAPACITY 2015	127	MW
PV PENETRATION	0,1	%

The PV power installation rate in Sweden continued to increase in 2015 for the 5th year in a row and as a total of 47,4 MW was installed. The Swedish PV market grew 31%, as compared to the 36,2 MW that were installed in 2014. The total installed capacity reached the 100 MW mark under 2015 as the total installed capacity was 126,8 MW at the end of 2015.

The off-grid market increased slightly to around 1,5 MW. As in 2014, and in the same way as in many European countries, the large increase of installed systems occurred within the submarket of grid-connected systems. With 45,8 MW installed in 2015 for grid-connected PV, the cumulative grid-connected PV reached 115,7 MW while the off-grid capacity established itself at 11,04 MW at the end of 2015. The strong growth in the Swedish PV market is due to lower system prices, a growing interest in PV and a direct capital subsidy along with newly introduced tax deduction system.

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 nine 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 (1,6 MW installed in 2015).

Incentives

A direct capital subsidy for installation of grid-connected PV systems that have been active in Sweden since 2009. It was first prolonged for 2012 and later extended until 2016. These funds were completely used in 2014 already, which pushed the government to add 50 MSEK for 2015. Due to the much higher interest in the support scheme, as compared to the allocated budget, the waiting time for a decision about the investment subsidy is quite long, in general about 1-2 years. In an effort to lower the waiting times the government decided in the autumn of 2015 to greatly increase the annual budget of this scheme for the years 2016–2019 with 235, 390, 390 and 390 MSEK, respectively.

Net-metering has been discussed and investigated several times but it has not been introduced. In the meantime, some utilities have decided to put in place different compensation schemes for the excess electricity of micro-producers. In addition, from 2015 the government introduced a tax deduction of 0,06 EUR per kWh for the excess electricity fed into the grid, which PV owners with a fuse below 100 ampere is entitled to. This remuneration is in addition to the compensation offered by the utility company. The tax deduction will apply on the income tax, and has a cap of 3 100 EUR per year.

Additionally, a tradable green certificates scheme exists since 2003, but only around 48,6 MW of the 115,7 MW of grid-connected PV installations in Sweden are using it so far due to the complexity for micro-producer to benefit from the scheme. It is expected that the Swedish green electricity certificate system will be prolonged to 2030.

The Swedish PV market is in the short term expected to continue to grow with the introduction of the tax deduction for micro-producer, the increase of supports from utilities and the increased budget for the investment subsidy. However, the administrative burden and long queue in getting investment subsidy need to be addressed properly in order for market to thrive in the upcoming years.

SWITZERLAND

FINAL ELECTRICITY CONSUMPTION 2015	58	TWh
HABITANTS 2015	8	MILLION
AVERAGE PV YIELD	995	kWh/kW
PV INSTALLATIONS IN 2015	333	MW
PV CUMULATIVE INSTALLED CAPACITY 2015	1 394	MW
PV PENETRATION	2,4	%

333 MW were connected to the grid in Switzerland in 2015, a slight increase compared to 2014 or in other words, a stable PV market. Almost 100% of the market consists of rooftop applications and the few ground mounted PV applications are, with one exception of 6 MW, small in size. Approximately 1,4 GW of grid-connected applications were producing electricity in the country at the end of 2015 whereas the off-grid applications market stood at level of less than 5 MW.

Switzerland has the national capped FiT scheme financed through a levy on electricity prices but the main drivers for 2015 market development were self-consumption and the direct subsidy scheme for small installations up to 30 kW introduced in 2014. The direct subsidy has been very successful and gained a market share of about 25% at the end of 2015. Systems below 10 kW are not eligible anymore for the FiT since 2014.

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 2015 the cantons agreed that in the future residential buildings must install 10W of PV per square meter heated area and some cantons introduced direct subsidies for storage.

BAPV represented 85% of the market in 2015, with BIPV around 15% thanks to a special premium offered by Swiss FiT and direct subsidy scheme.

EUROPE / CONTINUED

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 10 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. PV contributed to 1,9 % of the total electricity consumption in 2015 and will be able to cover at least 2,4 % in 2016.

OTHER COUNTRIES

4,1 GW of PV systems have been installed in 2015 in the United Kingdom (UK), bringing the total installed capacity to 9,5 GW. The UK was again the first European market in 2015, ahead of Germany, due to a strong deployment of utility-scale PV. This 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 "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. 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 (CfD) to guarantee a fixed remuneration based on a variable wholesale electricity price. So far this CfD system has failed to lead to a significant market development. The UK market is expected to decrease in 2016 significantly and even more in a near future due to the changes in incentives.

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, 2 MW in 2014 and 1 MW in 2015.

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, installations stopped and the total installed capacity was even revised downwards at the end of 2015. Composed mainly of large utility-scale installations, the Czech PV landscape left little place to few residential rooftop installations. At the end of 2015, the energy regulators used the false excuse (that European institutions should validate the Fit payments) to discontinue paying the FiT to existing plants, one more attempt, after the tax on FiT, to reduce the cost of previous FiT expenses. And to reduce the confidence of investors into PV in Czech Republic.

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. The market continued the downward trend with 10 MW installed in 2015. 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. The market reached 102 MW in 2015. 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 2015, driven by a mix of FiTs, self-consumption measures and calls for tenders that 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. Hungary installed some dozens of MW in 2015, at a level comparable with Poland.

In total, the European markets represented 8,6 GW of new PV installations and 97,8 GW of total installed capacity in 2015.

MIDDLE EAST AND AFRICA

Continuing the rising development trend started in 2014, many countries had considered PV as one of the main renewable source in producing electricity in 2015. Several countries are defining PV development plans and the prospects on the short to medium term are positive. The Middle East is now the most competitive place for PV installations, with PPAs granted through tendering processes among the lowest in the world.

ISRAEL

FINAL ELECTRICITY CONSUMPTION 2015	55	TWh
HABITANTS 2015	8	MILLION
AVERAGE PV YIELD	1 750	kWh/kW
PV INSTALLATIONS IN 2015	205	MW
PV CUMULATIVE INSTALLED CAPACITY 2015	886	MW
PV PENETRATION	2,8	%

Israel installed around 200 MW of new PV systems in 2015, the same capacity as in 2014. The country installed 244 MW in 2013, 47 MW in 2012 and 120 MW in 2011, which shows a rather stable market in the last years. In total, more than 800 MW of PV systems were operational in Israel at the end of 2015.

After years of PV development in the distributued segments, a first utility-scale plant was connected to the transmission grid (37,5 MW) in december 2014. Two large scale plants were connected in 2015, Halutziot with 55 MW and Ketura Solar with 40 MW. Most of the new installations continued to be medium size: between 500 kW to several MW with connection to the distribution grid, and can therefore be considered as distributed applications even if they are not always installed on buildings.

Competitiveness of PV benefits from a high irradiation level. However, 2015 has seen a dramatic decline in the electricity prices (around 15%), mainly due to the use of natural gas as the main fuel, which complicates the competitiveness of renewable sources.

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.

Government support is given in the form of guaranteed FiT for 20-25 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. Israel is trying a new bidding system for the FIT in PV project based on quota and price. Current starting price for this system is 0,27 ILS per kWh (0,07 USDcents).

Because FiT includes a subsidy, which is paid by the electricity consumer, there are quotas (Caps) for each renewable energy category, which might be expanded in 2016. While quotas are technology neutral, it is expected that most of the new RES generation will come from solar PV which is currently the most readily available renewable energy source in Israel.

Self-Consumption.

In 2013, a net-metering scheme was implemented for all RES with a cap of 400 MW. This programme was extended to 2020 and in early 2016 the PUA came out with a hearing aiming to increase the net metering cap to 700 MW. The scheme is a rather traditional net-metering scheme with credits valid during 24 months. However the credits are time-of-use dependent. Credits can be transferred to another consumption account, as long as it belongs to the same legal entity. The scheme contains an option that allows to sell a part of the electricity to the grid rather than getting a credit, but at a rather low price (currently 0,30 NIS/kWh).

Some additional grid charges and regulations are in place:

- 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.

MIDDLE EAST AND AFRICA / CONTINUED

TURKEY

FINAL ELECTRICITY CONSUMPTION 2015	214	TWh
HABITANTS 2015	77	MILLION
AVERAGE PV YIELD	1 527	kWh/kW
PV INSTALLATIONS IN 2015	208	MW
PV CUMULATIVE INSTALLED CAPACITY 2015	266	MW
PV PENETRATION	0,2	%

Once a very small PV market, Turkey aims now to reach 5 GW of PV installations by the end of 2023 according to its Strategy Plan (2015 - 2019) and to increase its electricity production capacity from solar power to 10 GW until 2030. This was clearly mentioned in the the plans to be implemented according to Turkey's INDC. Following the upward development trend from the previous year, the Turkish PV market surged to 208 MW in 2015 compared to 40 MW installed in 2014. The market increased mainly thanks to unlicenced projects. More than 2 GW of projects have already received the approval and might be built in the coming months. Cumulative grid-connected installed PV power in Turkey reached 266 MW at the end of 2015. As the speed of installations accelerates, the medium scenario for PV development in 2016 see the market in Turkey going much higher than in 2015.

Turkey considers two different procedures to install PV: licenced projects without size limit and unlicensed projects, which are limited to 1 MW. To date, only unlicensed PV plants have been installed in Turkey. Given the complexity of the process in the past, some investors preferred to set up MW-scale PV plants unlicensed. Such limits apply for projects that inject electricity into the grid but projects self-consuming all of their PV production are not limited in size.

The government intends to control PV development through the licensing process. In the first license round, 13 MW and 587 MW received their preliminary licenses in 2014 and 2015 respectively. It can be expected that the new capacity for licensed projects will be unlocked by 2016. 1 000 MW are expected in 2016.

The remuneration of PV projects is based on a traditional FiT system paid 13,3 USDcents/kWh during 10 years, with different levels according to the share of local production: PV modules, cells, inverters, installation and construction can benefit from an additional FiT which may reach up to 6,7 USDcents/kWh .

As of 19 December 2015, PV module imports will be charged an import tax, based on weight – specifically 35 USD/kg. An exemption from the tax exists by presenting an "Investment Incentive Certificate" for the approved projects which already received this certificate before December 2015.

Solar Energy is the most important alternative energy resource which is still untapped in Turkey with a potential of dozens of GW. Given the current support from the government, a rapidly growing market in Turkey, in near future, will not be surprising.

OTHER COUNTRIES

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 and few of them a significant increase. 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.

South Africa became the first African PV market in 2014 with around 922 MW installed, mostly ground mounted, but the momentum did not last and at the end of 2015, the total installed capacity reached 960 MW. The large majority of this capacity has been in large scale ground mounted systems, while the rooftop solar photovoltaic (RTPV) market, despite its enormous potential, remains dormant. Small distributed generators like RTPV have the potential to grow rapidly (around 500 to 1 000 MW annually), as only small financial investments per project are required and project planning can hypothetically be performed quite quickly.

The indicative installed capacity of small scale embedded generation (SSEG) in South African municipalities is in the order of 17 MWp.

The Renewable Energy Independent Power Producer Procurement Programme (REIPPP) has been the driver of PV installations in South Africa through a series of tendering processes that will continue to power up PV development in the coming years.

The fastest mover is Egypt, which has announced plans to develop PV. A FiT program targets 2,3 GW of installations (2 GW 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 and for sure in the distributed segments.

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. The market hit 268 MW in 2015.

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

Winning bids in tenders in the United Arab Emirates and Jordan have reached extremely low levels down to below 0,03 USD/kWh. Dubai will install 1 000 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. 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 but the country is expected to launch its first tender in 2016.

TABLE 2: PV INSTALLED CAPACITY IN OTHER MAJOR COUNTRIES IN 2015

COUNTRY	ANNUAL CAPACITY 2015 (MW)	CUMULATIVE CAPACITY 2015 (MW)
UK	4 105	9 582
INDIA	2 100	5 146
PAKISTAN	659	778
CHILE	446	848
HONDURAS	391	391
ALGERIA	268	268
TAIWAN	227	842
RUSSIA	185	199
PHILIPPINES	110	143
ROMANIA	102	1 332

SOURCE IEA PVPS & OTHERS.

TABLE 3: 2015 PV MARKET STATISTICS IN DETAIL

COUNTRY	2015 ANNUAL CAPACITY (MW)				2015 CUMULATIVE CAPACITY (MW)			
	GRID-CONNECTED DECENTRALIZED	GRID-CONNECTED CENTRALIZED	OFF-GRID	TOTAL	GRID-CONNECTED DECENTRALIZED	GRID-CONNECTED CENTRALIZED	OFF-GRID	TOTAL
AUSTRALIA	709	288	25	1 022	4 580	356	173	5 109
AUSTRIA	152	0	0	152	932	0	6	937*
BELGIUM	94	3	0	97	2 594	656	0	3 250
CANADA	195	480	0	675	736	1 783	61	2 579
CHINA	1 390	13 740	20	15 150	6 060	37 120	350	43 530
DENMARK	50	131	0	181	646	139	2	787
FINLAND	5	0	0	5	13	0	0	13
FRANCE	294	593	0	887	4 257	2 302	30	6 589
GERMANY	855	605	0	1 461*	29 214	10 446	50	39 710
ISRAEL	51	154	0	205	468	414	4	886
ITALY	264	34	2	300	7 500	11 392	14	18 906
JAPAN	6 400	4 409	2	10 811	24 624	9 399	127	34 150
KOREA	87	924	0	1 011	434	3 058	0	3 493*
MALAYSIA	25	2	0	27	228	2	0	230
MEXICO	0	56	0	56	0	156	14	170
NETHERLANDS	402	35	0	437	1 517	43	0	1 560
NORWAY	2	0	1	2*	3	0	12	15
PORTUGAL	14	32	3	49	166	291	8	465
SPAIN	40	0	14	54	3 105	2 202	124	5 430*
SWEDEN	44	2	2	47*	110	6	11	127
SWITZERLAND	333	0	0	333	1 387	3	4	1 394
THAILAND	0	121	0	121	0	1 390	30	1 420
TURKEY	0	208	0	208	12	254	0	266
USA	3 145	4 138	0	7 283	11 718	13 882	0	25 600
TOTAL IEA PVPS COUNTRIES	14 551	25 954	70	40 576	100 304	95 293	1 020	196 617
NON IEA PVPS COUNTRIES				9 854				28 758
REST OF THE WORLD ESTIMATES				225				2 360
TOTAL				50 655				227 736

NOTES:
* THE DIFFERENCE IS DUE TO ROUND UP.

SOURCE IEA PVPS & OTHERS.

TRENDS 2016 GLOBAL PV MARKET AT THE END OF 2015: 228 GW

CANADA

	MW	%
ANNUAL MARKET 2015	675	1,3
GRID-CONNECTED CENTRALIZED	1 783	69,1
GRID-CONNECTED DECENTRALIZED	736	28,5
OFF-GRID	61	2,4
CUMULATIVE MARKET 2015	2 579	1,1

UK

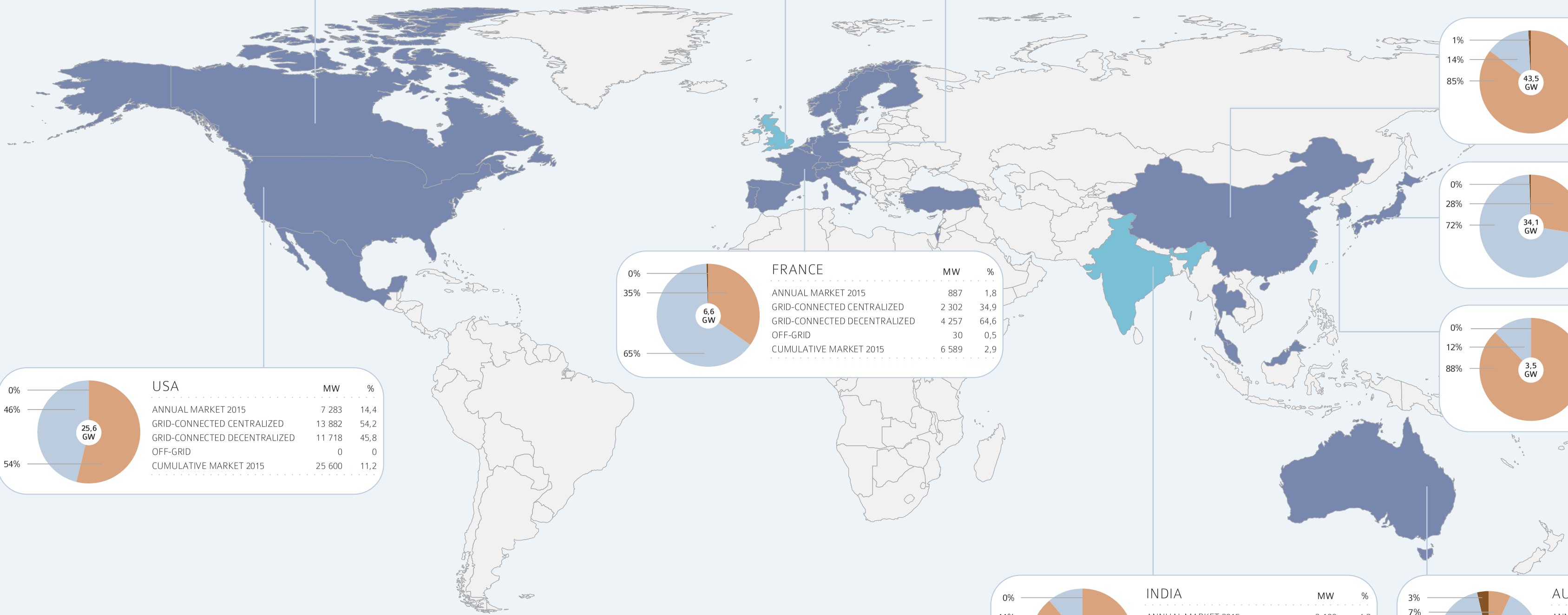
	MW	%
ANNUAL MARKET 2015	4 105	8,1
GRID-CONNECTED CENTRALIZED	4 766	49,8
GRID-CONNECTED DECENTRALIZED	4 815	50,3
OFF-GRID	0	0
CUMULATIVE MARKET 2015	9 582	4,2

GERMANY

	MW	%
ANNUAL MARKET 2015	1 461	2,9
GRID-CONNECTED CENTRALIZED	10 446	26,3
GRID-CONNECTED DECENTRALIZED	29 214	73,6
OFF-GRID	50	0,1
CUMULATIVE MARKET 2015	39 710	17,4

CHINA

	MW	%
ANNUAL MARKET 2015	15 150	29,9
GRID-CONNECTED CENTRALIZED	37 120	85,3
GRID-CONNECTED DECENTRALIZED	6 060	13,9
OFF-GRID	350	0,8
CUMULATIVE MARKET 2015	43 530	19,1



FRANCE

	MW	%
ANNUAL MARKET 2015	887	1,8
GRID-CONNECTED CENTRALIZED	2 302	34,9
GRID-CONNECTED DECENTRALIZED	4 257	64,6
OFF-GRID	30	0,5
CUMULATIVE MARKET 2015	6 589	2,9

JAPAN

	MW	%
ANNUAL MARKET 2015	10 811	21,3
GRID-CONNECTED CENTRALIZED	9 399	27,5
GRID-CONNECTED DECENTRALIZED	24 624	72,1
OFF-GRID	127	0,4
CUMULATIVE MARKET 2015	34 150	15

USA

	MW	%
ANNUAL MARKET 2015	7 283	14,4
GRID-CONNECTED CENTRALIZED	13 882	54,2
GRID-CONNECTED DECENTRALIZED	11 718	45,8
OFF-GRID	0	0
CUMULATIVE MARKET 2015	25 600	11,2

KOREA

	MW	%
ANNUAL MARKET 2015	1 011	2,0
GRID-CONNECTED CENTRALIZED	3 058	87,6
GRID-CONNECTED DECENTRALIZED	434	12,4
OFF-GRID	0	0
CUMULATIVE MARKET 2015	3 493	1,5

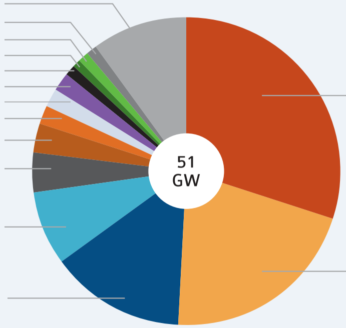
INDIA

	MW	%
ANNUAL MARKET 2015	2 100	4,2
GRID-CONNECTED CENTRALIZED	4 561	88,6
GRID-CONNECTED DECENTRALIZED	585	11,4
OFF-GRID	0	0
CUMULATIVE MARKET 2015	5 146	2,3

AUSTRALIA

	MW	%
ANNUAL MARKET 2015	1 022	2,0
GRID-CONNECTED CENTRALIZED	356	7,0
GRID-CONNECTED DECENTRALIZED	4 580	89,6
OFF-GRID	173	3,4
CUMULATIVE MARKET 2015	5 109	2,2

GLOBAL PV MARKET IN 2015



TOP 10 GLOBAL PV MARKET 2015

LEGEND

- IEA PVPS countries
- Non IEA PVPS countries

GRID-CONNECTED CENTRALIZED
GRID-CONNECTED DECENTRALIZED
OFF-GRID
XX GW = CUMULATIVE MARKET 2015

Apex, Silicon-Film (trademark) SunUPS System; 4.8 kW rated peak array capacity; Belmont, California. © AstroPower, Inc

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 2015, the price of PV systems, as noted, 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 or below 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, which will have a tremendous impact on the future of PV as an electricity source for rural electrification.

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.

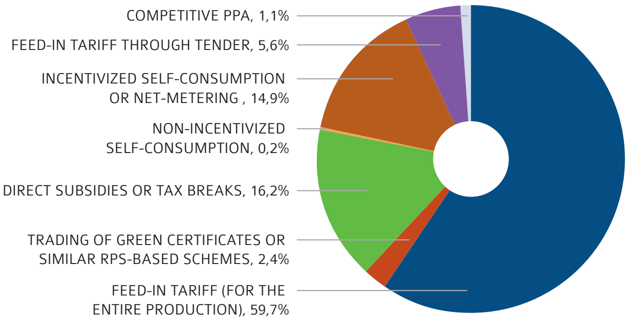
MARKET DRIVERS IN 2015

Figure 12 shows that about only 1,3% of the world PV market has been driven by pure self-consumption or the sole competitiveness of PV installations in 2015. It also means 98,7% of the global PV market depends either on support schemes or adequate regulatory frameworks. This number has slightly increased compared to the 96% seen in 2014 due to a finer understanding of some regulations but as a whole the global PV market remains incentives or regulatory driven.

In 2015 a large part of the market still remained dominated by FiT schemes (59,7%, down from 63%) granted without a tendering process. If 5,6% is added of PV installations granted through a tendering process, the share of PV installations receiving a predefined tariff for part or all of their production increased slightly. Subsidies aiming at reducing the upfront investment (or tax breaks), used as the main driver for PV development represented around 16% of the installations, stable compared to 2014. Incentivised self-consumption including net-billing and net-metering was the main incentive in 2015 for 14,9% 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. Green certificates and similar schemes based on RPS represented only a minority of the market with 2,4%.

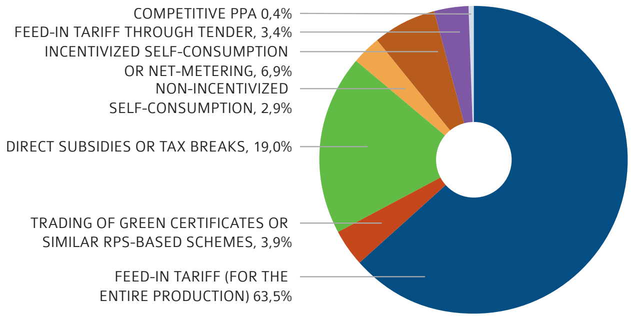
MARKET DRIVERS IN 2015 / CONTINUED

FIGURE 12: 2015 MARKET INCENTIVES AND ENABLERS



SOURCE IEA PVPS & OTHERS.

FIGURE 13: HISTORICAL MARKET INCENTIVES AND ENABLERS



SOURCE IEA PVPS & OTHERS.

Historically, the dominance of FiTs and direct subsidies is similar but even more visible in Figure 13.

The emergence of calls for tenders has been confirmed again in 2015, with new countries using this legal tool to attribute remunerations to PV projects under certain conditions. Peru, Mexico, Abu Dhabi (UAE) 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 2015 and is increasing. Such tenders can take various forms, and integrate often additional obligations for the bidder, which are sometimes used to protect the local market.

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 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. In Germany, in order to maintain the financing of the system, prosumers are now, above 10 kW required to pay 40% of this levy on the electricity consumption coming from PV.

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 in the past, which led to fast market development in Japan, China, 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 0,25 DKK/kWh and the total cost amounted to 8,4 BDKK in 2015. It is paid by electricity consumers. By mid 2016 the government proposed to give up the PSO scheme and use the state budget instead, but this proposal is still in the political process.

France: The CSPE surcharge part for PV amounted to 2,24 BEUR in 2015, or around 1,65 EURcts/kWh. In 2015, the CSPE surcharge stood at 19,5 EUR/MWh. Furthermore, in support of the Energy Transition, the Energy Transition Financing Fund (Fonds de financement de la Transition énergétique) has been raised to 1,5 BEUR.

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. In 2015, EEG surcharge was 6,17 EURcts/kWh, which is twice more than initial value of EEG surcharge in 2014 - 2,54 EURcts/kWh. To be in detailed, 2,7 EURcts/kWh of this surcharge covers for PV. However, from January 2016, the total surcharge amounted to 6,35 EURcts/kWh and end users must pay value added tax (19%) on this surcharge so that the costs imposed on private households increases to 7,56 EURcts/kWh.

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: Surcharge to promote renewable energy power generation for an household was set at 1,58 JPY/kWh in April 2016 and 2,25 JPY/kWh from May 2016 to April 2017. High-volume electricity users such as manufacturers are entitled to reduce the surcharge. Amount of purchased electricity generated by PV systems under the FIT program is around 56,4 TWh as of the end of January 2016, exceeding 2,3 TJPY in total.

Malaysia: Consumers above 300 kWh/month are paying a surcharge for the RE Fund that finances the FiT. This represented around 1,6% imposed on electricity price paid by retail consumers in 2015. The rest of the fiscal and monetary support draws from the Government's consolidated fund.

Spain: The surcharge for all renewables accounted for 2,3% of the total electricity bill for industrial consumers and 6,5% for household consumers. In 2015, the total amount collected to support PV was 2 434,96 MEUR.

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, Japan, Germany and Italy (until 2013), to mention a few. The attractiveness of FiT has been slightly reduced but they still drive a large part of the PV market. While FiT still represent more than 60% of the 2015 PV market, they have lost ground in European countries where they are mostly constrained.

National or Local

Depending on the country specifics, FiT can be defined at national level (China, Japan, Germany, 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.

Automatic or Ad Hoc Adjustment

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 to a certain extent in China in 2015 and probably in 2016, as well as 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 2016, due to a low market level and unachieved targets, the FiT will not be decreased 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. However few countries have opted for a clear decrease strategy and adapt their FiT on a regular basis, such as Japan or China.

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.

Tendering

Calls for tender are another way to grant FiT schemes with an indirect financial cap. This system has been adopted in many countries around the world, with the clear aim of reducing the cost of PV electricity. Since bidders have to compete one with each other, they tend to reduce the bidding price at the minimum possible and shrink their margins. This process is currently showing how low the bids can go under the constraint of competitive tenders. Most continents are now using such a way to deploy PV at the lowest possible cost. However, many believe such low bids are possible with extremely low capital costs, low components costs and a reduced risk hedging. Since they represented 5,6% of all PV installations in 2015 (but this should increase in the coming years), it is conceivable that they do not represent the fair PV price in all cases but showcases for super-competitive developers.

They have spread in the entire world in the last years and Europe did not escape this with France using it for some market segments (above 100 kW in a simplified version and above 250 kW in all cases) and Germany is using it utility-scale plants. In Latin America, Peru, Mexico, Brazil just to mention the most visible, such tenders have been implemented. In India or the UAE, the bids are reaching extremely low levels, below 30 USD/MWh in the best case. South Africa, Jordan, the USA and many others have implemented that system.

The tendering process that grants a PPA (which is nothing else than a FiT) can be a competitive one (most cases) or simply an administrative procedure (Turkey). The competitive tenders can be organized as pay-as-bid (the best offers get the bid they have proposed) or

MARKET DRIVERS IN 2015 / CONTINUED

pay-as-clear (the lowest one). 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 proposed as a seasonal price. It can be technology specific (Germany, France, South Africa, etc.) or technology neutral (the Netherlands, Poland, UK). In this last case, PV is put in competition with other generation sources, with little success until now, but the situation could change in the coming years with PV becoming the cheapest source of electricity.

Additional Constraints

The ease of implementing FiT allows its use when PV is approaching competitiveness: Germany added a 90% cap in 2012 to the amount of electricity that could benefit from the FiT system, pushing for either selling the excess on the electricity market (at a quite low price, around 3 to 8 USDcents in 2015), 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, but also in Germany or in Japan for systems below 10 kW.

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. The easiness of implementation continues to make it the most used regulatory framework for PV globally.

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 wholesale 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

TABLE 4: THE MOST COMPETITIVE TENDERS IN THE WORLD UNTIL Q3 2016

REGION	COUNTRY/STATE	USD/MWh
LATIN AMERICA & CARRIBEAN	CHILE	29,1
MIDDLE EAST	UNITED ARAB EMIRATES	29,9
LATIN AMERICA & CARRIBEAN	MEXICO	35,5
LATIN AMERICA & CARRIBEAN	PERU	49
MIDDLE EAST	UNITED ARAB EMIRATES	58
MIDDLE EAST	JORDAN	61
SUB-SAHARAN AFRICA	SOUTH AFRICA	65
LATIN AMERICA & CARRIBEAN	CHILE	65
SOUTH ASIA	INDIA	67

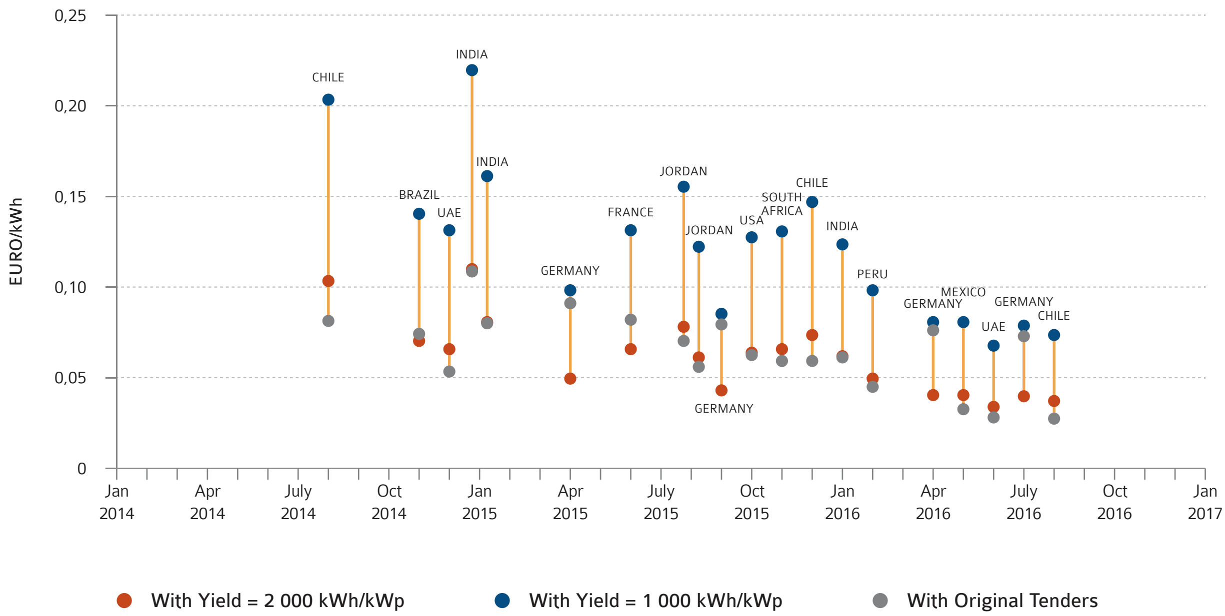
SOURCE IEA PVPS & OTHERS.

(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. In China, FiPs are based on the coal power price.

Private PPAs

While FiT are paid in general by official bodies or utilities, looking for PPAs is compulsory in some countries. In Chile for instance the PV plants built in the northern desert of Atacama had to find PPAs with local industries in order to be beneficial. Such plants can be considered as really competitive since they rely on PPAs with private companies rather than official FiT schemes.

FIGURE 14: NORMALIZED PPA VALUE FOR RECENT TENDERS



SOURCE IEA, BECQUEREL INSTITUTE.

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 Austria, Australia, Belgium, Sweden, Japan, Italy and China; just to mention a few. 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 residential segment. The debate was intense in the USA in 2015 whether or not extending the ITC (Investment Tax Credit) or to phase it out rapidly. Finally, the decision was taken to continue the current scheme at least until the end of the decade.

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 was still using a system called ROC (Renewable Obligation Certificates) for large-scale PV in 2015, but it will be replaced in 2016. 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 and the impact they will have on PV development in the coming years is still unknown.

CARBON TAXES

Some attempts have been made to impose carbon taxes as a way to support the development of renewables indirectly by putting an additional cost on CO_2 emitting technologies. The most important regulation has been the Emission Trading System in Europe (ETS) which aims at putting a price on the ton of CO_2. So far it has failed to really incentivized the development of PV or any other renewable source because of the low carbon price that came out of the system due to its flaws. Whether that system will be reviewed in the coming years is still unknown. Carbon pricing was in effect in Australia from 2011 until 2014. Canada is discussing the implementation of a carbon tax as this publication goes to press. In September 2015, China announced that its own cap-and-trade carbon program could enter into force in 2017. In general, the conclusion of an agreement during the COP21 in Paris in 2015 has signalled the start of a potential new era for carbon free technologies and the need to accelerate the transition to a carbon-free electricity system. In this respect, PV would greatly benefit from a generalized carbon price, pushing CO_2 emitting technologies out of the market.

SUSTAINABLE BUILDING REQUIREMENTS

With around 40% 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

UPFRONT INCENTIVES / CONTINUED

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. In all member states of the European Union, the new Energy Performance in Buildings Directive (EPBD) will impose to look for ways to decrease the local energy consumption in buildings, which could favor decentralized energy sources, among which PV appears to be the most developed one, from 2020 onwards.

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, now that competitiveness has improved in many countries.

SELF-CONSUMPTION SCHEMES

With around 40% of distributed PV installations in 2015, 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 PV system owner's electricity bill, 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.

In order to better compare existing and future self-consumption schemes, the IEA PVPS published a comprehensive guide to analyze and compare self-consumption policies. This "Review of PV Self-Consumption Policies" proposes a methodology to understand, analyze and compare schemes that might be fundamentally diverse, sometimes under the same wording. It also proposes an analysis of the most important elements impacting the business models of all stakeholders, from grid operators to electric utilities.

Self-consumption

Pure self-consumption exists in several countries and in particular 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. Self-consumption implies revenues coming from savings on the electricity bill. These revenues can be decreased if grid taxes and some levies are to be paid in any case by the prosumer, on the self-consumed electricity. Even if these measures appear rather unfair for prosumers and tend to show how fierce the opposition from conventional electricity stakeholders could be, they were applied in 2015 in some countries, such as Germany, Spain or Belgium.

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 minute 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:

- The lowest remuneration is 0: excess PV electricity is not paid while injected (Spain, Thailand pilot project);
- Excess electricity gets the electricity market price, with or without a bonus (Germany);
- A FiT remunerates the excess electricity (Japan below 10 kW, Germany, Italy) at a predefined 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 until now. 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 implemented net-metering schemes or will do so in 2016 (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 and then reintroduced. While these taxes 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 electricity's supply and demand. 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 2015, around 7 GW out of 38 GW PV 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 but prices have started to go down in some key markets, such as Japan or the USA. In these two markets 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. Moreover, it seems that additional regulations in some countries have a tendency to increase the soft costs compared to the best cases. This will have to be scrutinized in the coming years to avoid eating up the gains from components price decrease.

INNOVATIVE BUSINESS MODELS

Until recently, a large part of the PV market was based on traditional business models based on the ownership of the PV plant. For rooftop applications, it was rather obvious that the PV system owner was the owner of the building. But the high upfront capacity requirements are pushing different business models to develop, especially in the USA, and to a certain extent in some European countries. PV-as-a-service contributes significantly to the residential US market for instance, with the idea that PV could be sold as a service contract, not implying the ownership or the financing of the installation. These business models could deeply transform the PV sector in the coming years, with their ability to include PV in long term contracts, reducing the uncertainty for the contractor. Such business models represent already more than 50% of the residential market in the USA, and some German, Austrian or Swiss utilities are starting to propose them, as we will see below. However, the US case is innovative by the existence of pure-players proposing PV (such as SolarCity, Vivint...) as their main product. Since it solves many questions related to the financing, the operations and reduces the uncertainty on the long term for the prosumer, it is possible that such services will develop in a near future, as the necessary developments that will push the distributed PV market up.

GRID INTEGRATION

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. 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. In Europe or Australia, specific grid codes have been adapted for PV and more will come. In Mexico, specific grid requirements have in some cases be imposed to bidders in tendering processes. In any case, grid integration policies will become an important subject in the coming years, with the need to regulate PV installations in densely equipped areas.

ELECTRICITY STORAGE

In the current stage of development, electricity storage remains to be incentivized to develop. While some iconic actors are proposing trendy batteries, the real market remains more complex and largely uncompetitive without financial support.

In the USA, California has led efforts for energy storage deployment, as it is the nation's leading market for distributed PV deployment. Its current Self-Generation Incentive Program offers rebates for "advanced energy storage" at 1,31 USD/Wp. To-date it has funded approximately 27 MW of storage, and in 2016 over 117 MW of storage should benefit from these rebates. In addition, the Hawaii Electric Company installed 1 MW of distributed storage in September 2014 as a pilot project to test the feasibility of using energy storage to respond to demand spikes. The Hawaiian self-consumption program also provides a self-supply option, where PV owners can gain preferential permitting treatment by consuming all PV onsite (no value is given to exported generation).

In Australia, storage incentives were offered by the City of Adelaide and the City of Melbourne in 2015. The City of Adelaide provides 50% of the cost of batteries up to a value of AUD 5 000, plus up to a further AUD 5 000 for 20% of the price of a PV system.

In Germany, a financial subsidy for storage batteries are available for PV systems below 30 kW.

In Japan, there is a national subsidy for residential storage batteries. Prefabricated house manufacturers are active in promoting PV system with storage batteries. In Korea, the government is promoting the Energy Storage System business by designating the ESS as an energy related new industry item. It is reported that Korean players are making attempts to combine ESS and energy management business with renewable energy supply.

CONCLUSION

Once again in 2015, the most successful PV deployment policies based themselves on FiT policies or direct incentives (including tax breaks). The growth in Japan (FiT, self-consumption), 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. The projects granted through tenders have increased to reach more than 5% of the total and more are expected to come in the coming years.

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.

In parallel the difficulties of the distributed market which remained stable in the last five years concentrates the growth of the PV market in the utility-scale segment. However, the major outcome of 2015 consists again in the widespread use of tendering 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 slowly 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.

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)	0,04	0,13	-	0,21	0,10	0,06	-	0,07	0,09	-	-	0,26	-	-	0,13	-	-	0,07	-	-	0,15	0,17	0,11	+
HIGHEST FEED-IN TARIFFS LEVELS (USD/kWh)	0,45	0,20	-	0,30	0,16	0,09	-	0,28	0,14	-	-	0,30	-	-	0,34	-	-	0,16	-	-	0,26	0,20	0,11	+
INDICATED HOUSEHOLD RETAIL ELECTRICITY PRICES (USD/kWh)	0,16-0,29	0,22	0,22-0,26	0,06-0,14	0,07-0,10	0,33-0,36	0,13-0,20	0,17	0,32	0,15	0,21-0,27	0,21	0,11	0,11-0,14	0,06-0,15	0,23	0,06-0,12	0,18	0,12-0,22	0,12-0,21	0,18-0,26	0,07 - 0,13	0,17	0,13
DIRECT CAPITAL SUBSIDIES	+	-	R	R			+	R	+		R	+	+				+/*		-	+	+	+	+	+
GREEN ELECTRICITY SCHEMES	+	-	R	+					U	*		+				+				+	U			U
PV-SPECIFIC GREEN ELECTRICITY SCHEMES	+	+	R							*											+			
RENEWABLE PORTFOLIO STANDARDS	+											+	+				+			+				R
PV SPECIAL TREATMENT IN RPS													+											+
FINANCING SCHEMES FOR PV / INVESTMENT FUND	+	+							+		+	+				+								+
TAX CREDITS			+				+	-			+	+	+		+	+			-		+			+
NET-METERING / NET-BILLING / SELF-CONSUMPTION INCENTIVES	R	+	R	+	+	+	+	R	+	+	+	+		+		+		+/*	-	U	U		+	R
COMMERCIAL BANK ACTIVITIES	+				+/*			+	+		+	+			+				+/*		+	+		+
ELECTRICITY UTILITY ACTIVITIES	+			+	+/*	+/*	+		+		+	+	+		+					+	U/*			+
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 2015.
- THIS SUPPORT SCHEMES HAS BEEN CANCELED IN 2015.

SOURCE IEA PVPS.

A TetraSun PV cell. © Dennis Schroeder / NREL

four

TRENDS IN THE PV INDUSTRY

This chapter 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 the year 2015. This chapter provides an overview of the PV industry while a more detailed information of the PV industry in each IEA PVPS member country can be found in the relevant National Survey Reports.

A national overview of PV material production and cell/module manufacturing in the IEA PVPS countries during the year 2015 is presented in Annex 3 and is directly based on the information provided in the National Survey Reports of IEA member countries.

With the growth of the demand seen in 2015, the PV industry increased the level of shipments. While the market seemed slow in the first half of the year, key players reported improvement of business performance in the second half of the year. Major PV module manufacturers increased the manufacturing capacity in expectation of further growth from 2016 onwards. It is notable that trade conflicts still affect the strategies of selection for PV manufacturing sites. Plans for manufacturing outside of China have increased in 2015.

In that context, market prices for silicon feedstock, PV cells and modules continued to decline throughout 2015. As in recent years, some manufacturers have been seeking the way to make more profit through shifting focus to downstream business such as PV project development. Some companies have created specific subsidiaries called "YieldCo" to have access to cheaper finance, with various results.

THE UPSTREAM PV SECTOR (MANUFACTURERS)

This section reviews the trends of the value chain of crystalline silicon technology and thin-film PV technologies. While PV system consists of various steps and materials as shown in Figure 15, this section focuses on trends of polysilicon, ingot/wafer and PV modules (crystalline silicon and Thin film PV) and inverters.

Polysilicon Production

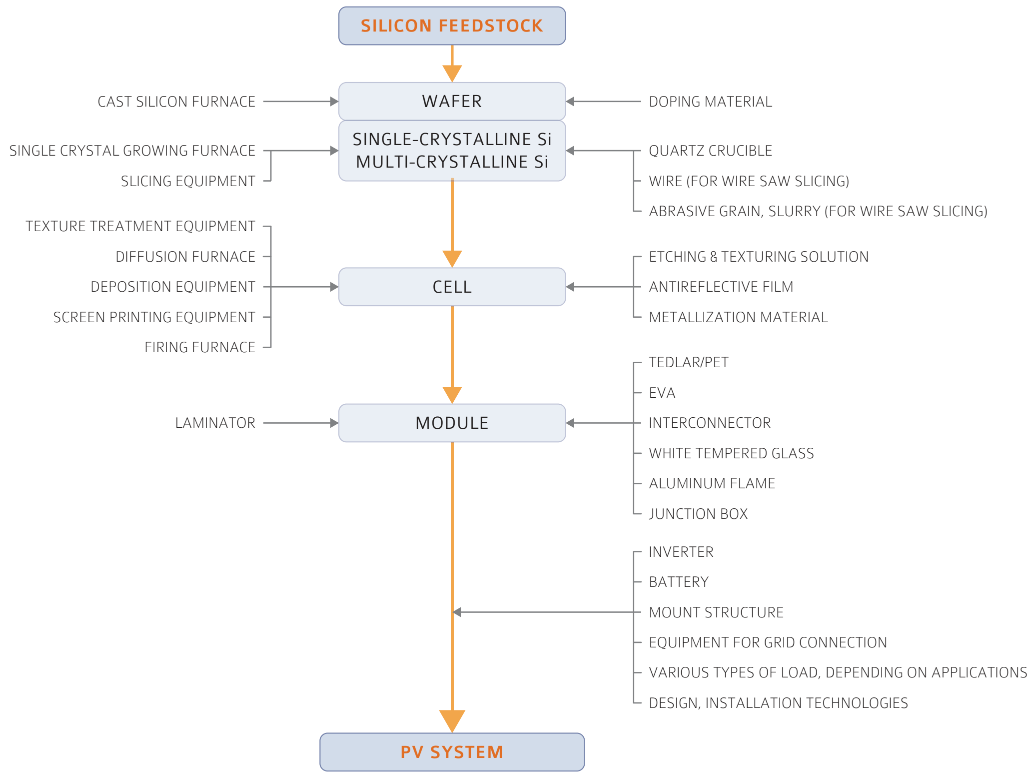
Wafer-based crystalline silicon technology remains dominant for making PV cells and the discussion in this section focuses on the wafer-based production processes. Although some IEA PVPS countries reported on production of feedstock, ingots and wafers, the pictures from the National Survey Reports of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

It is estimated that polysilicon production for solar cells increased from 235 000 tons in 2014 to 310 000 tons in 2015. Polysilicon production for semiconductor in 2015 was around 30 000 tons, or around 10% of the total production which makes PV today the largest consumer of polysilicon.

As of the end of 2015, global manufacturing polysilicon capacity reached around 446 000 tons. Out of which, the so-called Tier 1 producers claim to have more than 70%. Despite the gap between the capacity and demand, new plans for manufacturing polysilicon

THE UPSTREAM PV SECTOR / CONTINUED

FIGURE 15: PV SYSTEM VALUE CHAIN (EXAMPLE OF CRYSTALLINE SILICON PV TECHNOLOGY)



SOURCE IEA PVPS & OTHERS.

have continued to be reported and about 43 000 tons of new capacity was added in 2015. In 2016, the global manufacturing capacity is expected to reach a level of 453 000 tons.

In 2015, it is estimated about 330 000 tons of polysilicon were used for crystalline silicon solar cells considering that in average 5,6 g of polysilicon is used for a 1 W of solar cell (the lowest case being at 4 g per W).

The polysilicon spot price in the beginning of 2015 was around 20 USD/kg and it declined throughout the year to the level of 13 USD/kg in December 2015. While the spot prices showed a significant decline, some PV manufacturers procure polysilicon at higher prices under long term contract signed in time of tight polysilicon supply (2006 to 2010). These contracts still have an impact on PV module manufacturing cost for some manufacturers and has lead others to denounce such agreements.

Most of major polysilicon manufacturers adopt conventional technologies such as Siemens and FBR (Fluidized bed reactor) processes, which are used to supply polysilicon for the semiconductor industry. Production efficiency has been improved and energy consumption in 2015 reached less than 55 kWh/kg. This reduces by around 7% per year, coming from close to 80 kWh/kg in 2010.

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 benefit from these cost advantages, some of major companies are planning to enhance their capacities with the FBR process. Another lower cost process is metallurgical process that is directly produced from metallic silicon.

As well as in the previous year, major polysilicon producing IEA PVPS countries in 2015 were China, Germany, South Korea, USA, Japan, Malaysia and Norway. China continued to be the largest producer and consumer of polysilicon in the world. China reported that it produced 165 000 tons of polysilicon, a 21,3% increase over 136 000 tons in 2014, accounting for close to 50% of the global production. China also reported that it consumed 260 000 tons of polysilicon for solar cells and imported around 9 500 tons of polysilicon produced overseas, mainly from Germany, Korea and Malaysia, countries with low or no import-duties. The largest producer in China and globally is GCL-Poly Energy (Jiangsu Zhongneng Polysilicon Technology Development) that produced 74 000 tons in 2015. The second largest producer, TBEA Solar produced 21 000 tons. Other major manufacturers in China are China Silicon, Daqo New Energy, etc. Small scale polysilicon producers in China continued to halt the operation during last year because the spot price was too low to operate.

Germany had more than 60 000 ton/year of domestic polysilicon manufacturing capacity in 2015, which was running almost at full capacity to produce 58 000 tons of polysilicon in 2015. Wacker Chemie finally reached a capacity of 80 000 tons/year at the end of 2015 with the completion of a new plant aiming at producing 20 000 ton/year in the USA. It is expected to start shipping in 2016. South Korea reported 93 000 tons of production in 2015. The largest Korean producer OCI added 10 000 tons of capacity in 2015 and reached 52 000 ton/year in the end of the same year. Other main Korean producers are Hanwha Chemical, Hankook Silicon, and Samsung MEMC KCC. The USA increased their polysilicon manufacturing capacity from 70 000 ton/year to 90 000 ton/year with the new plant of Wacker Chemie. Other US manufacturers are Hemlock Semiconductor, REC Silicon and SunEdison (that went bankrupt in 2016 and sold to GCL). The polysilicon production in the USA decreased from 49 059 tons in 2014 to 34 853 tons in 2015 due to Anti-dumping Duties (ADs) imposed in China but also the difficulties of of SunEdison. Tokuyama of Japan produced 13 800 tons in Malaysia. The company has in total 20 000 tons of production capacity in Malaysia with standby capacity of 6 200 tons/year and production capacity of 13 800 tons/year.

Canada, the USA and Norway reported activities of polysilicon producers working on metallurgical process aiming at lowering the production cost. Silicor Materials in the USA have a plant in Canada and is building a manufacturing facility in Iceland. Elkem Solar in Norway produced 6 500 tons of polysilicon in 2015.

Ingot & Wafer

To make 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. In addition to major ingot/wafer manufacturers, some PV module manufacturers such as Yingli Green Energy (China), ReneSola (China), Trina Solar (China), SolarWorld (Germany), Panasonic (Japan), Kyocera (Japan), and some others also manufacture silicon ingots and wafers for their in-house production. 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 facilities are now procuring wafers from specialized manufacturers because of cost and quality advantages. In 2015, it can be estimated that over 60 GW of crystalline silicon wafers were produced.

In 2015, China produced 48 GW of solar wafers. It increased wafer production capacity from 50,4 GW/year in 2014 to 64,3 GW/year in 2015. GCL-Poly Energy is the largest producer of wafers in China and globally and produced 15 GW in 2015. Compared to China, manufacturing capacity in other IEA PVPS countries remain smaller: Korea (2 380 MW production), Japan (> 1,2 GW/year). Malaysia, Norway and the USA also reported wafer manufacturing activities. In non-IEA PVPS countries, Chinese Taipei (hereafter written as Taiwan) is a major producing country of solar wafers with more than 6,5 GW/year of production capacity. In total, 13 companies including solar cell manufacturers are active on the island. In Singapore, the Norwegian company REC Solar produces solar wafers for its own use in its Singaporean factory with about 1 GW/year of capacity.

The mc-Si wafer spot price was stable throughout 2015 with slight changes. The reported price at the beginning and end of 2015 was 0,87 USD/W and 0,86 USD/W. On the other hand, sc-Si price has decreased from 1,15 USD/W in January 2015 to 0,89 USD/W in December of the same year. Due to improvement of mc-Si wafer quality and PERC process, the price difference of mc- and sc-wafers narrowed in 2015. More than 18,5% of conversion efficiency is reported using advanced mc-Si wafers from GCL-Poly Energy (China) and Sino-American Silicon (Taiwan). Trina Solar (China) announced the World's highest efficiency of 21,25% using mc-Si wafer in November 2015. Due to the fact that investment in ingots/wafers is slower than investments in PV cell/module production, an upward trend of wafer prices was reported at the end of 2015, which was triggered by the expectation of demand growth in the first half of 2016.

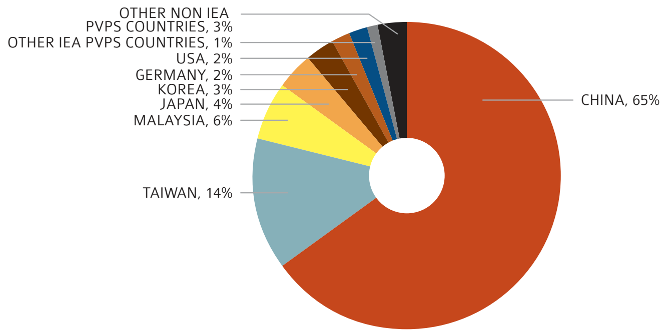
Cost down pathways of wafers are driven mainly by larger sized crucibles for mc-Si wafers (G7 generation crucible for 1 000 kg charging) and improvement of seed-crystals to reduce process time and increase yield. For slicing, diamond wire saws (DWs) contribute to get thinner-wafers and cost reduction mainly for sc-Si wafers. Startup companies in the USA and Europe are developing new processes to manufacture wafers without conventional wire-sawing. 1366 Technologies in USA announced that it achieved 19,1% of conversion efficiency using its wafers directory processed by melting polysilicon, the so-called kerfless wafer production.

Photovoltaic Cell and Module Production

Global PV cell (crystalline silicon PV cell and thin-film PV cell) production in 2015 is estimated to be around 63 GW. As well as the previous year, China reported the largest production of PV cells. Reported production of PV cells in China was about 41 GW in 2015, a 24 % increase over the previous year (33 GW). As shown in Figure 16, China's production volume accounts for 65 % of the world total. IEA PVPS countries producing PV cells are Malaysia, Japan, Germany, the USA, South Korea and to a lesser extent Netherlands and France. Major non-IEA PVPS countries manufacturing solar cells are Taiwan, the Philippines, Singapore and India. Taiwan has more than 10 GW of production capacity, the second largest capacity after China. Figure 17 shows the evolution of PV cell production volume in selected countries.

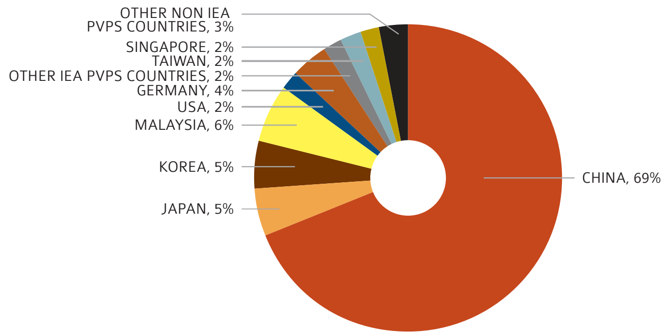
THE UPSTREAM PV SECTOR / CONTINUED

FIGURE 16: SHARE OF PV CELLS PRODUCTION IN 2015



SOURCE IEA PVPS, RTS CORPORATION.

FIGURE 19: SHARE OF PV MODULE PRODUCTION IN 2015



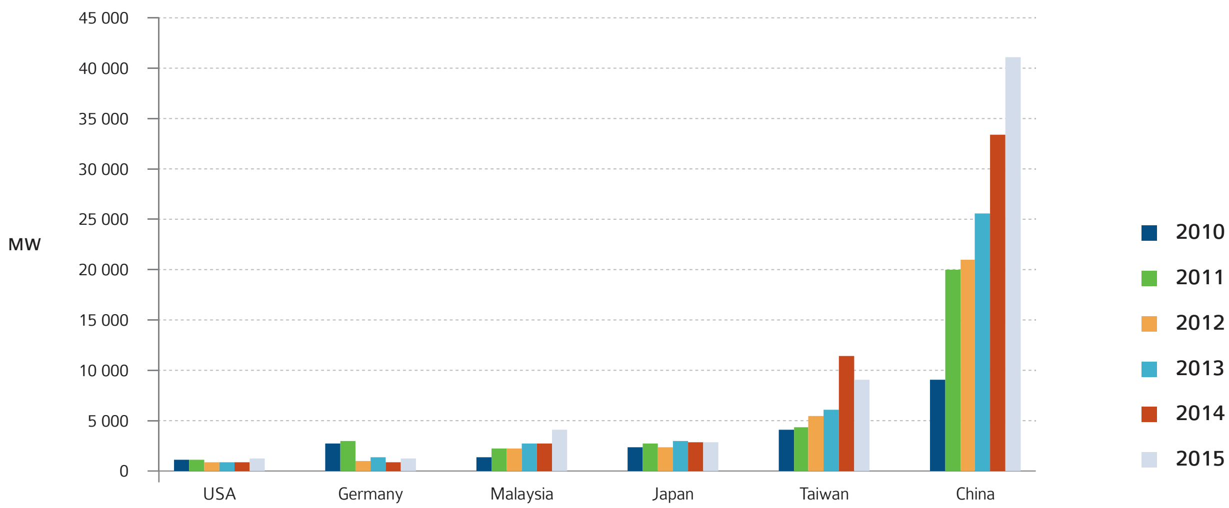
SOURCE IEA PVPS, RTS CORPORATION.

In 2015, the top 3 solar cell manufacturers produced more than 3 GW each. The No. 1 producer, Hanwha Q Cells, produced a total of 3 935 MW in its factories in China, Malaysia, Germany (which has been closed) and South Korea. Trina Solar and JA Solar in China followed, producing 3 884 MW and 3 600 MW respectively.

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 around 63 GW. More than 90% of PV modules were produced in IEA PVPS member countries. Figure 18 shows the trends of estimated global production capacity and production. Estimated utilization of global PV manufacturing capacity increased from 68% in 2014 to about 80 % due to the demand growth in 2015.

As shown in Figure 19, China was the largest producing country and accounted for 69 % of the global PV module production. Chinese companies manufactured 45,8 GW of PV modules. The largest producer in China and in the World in 2015 was Trina Solar as in 2014. The company shipped 5 873 MW of PV modules. Several PV module producing companies will achieve more than 5 GW/year in terms of production capacity in 2016. Major Chinese companies will enhance their production capacities overseas in Malaysia, Thailand, India, Vietnam, the Netherlands, Germany and Brazil in order to avoid ADs implemented following trade conflicts. As a result, PV module production bases have been more and more diversified. Jinko Solar started cell and module production in Malaysia in May 2015. Trina Solar inaugurated its Thailand factory in March 2016. JA Solar is also planning to invest into a production plant in Thailand.

FIGURE 17: EVOLUTION OF THE PV INDUSTRY IN SELECTED COUNTRIES - PV CELL PRODUCTION (MW)



SOURCE IEA PVPS, RTS CORPORATION.

FIGURE 20: PV MODULE PRODUCTION PER TECHNOLOGY IN IEA PVPS COUNTRIES 2011-2015 (MW)

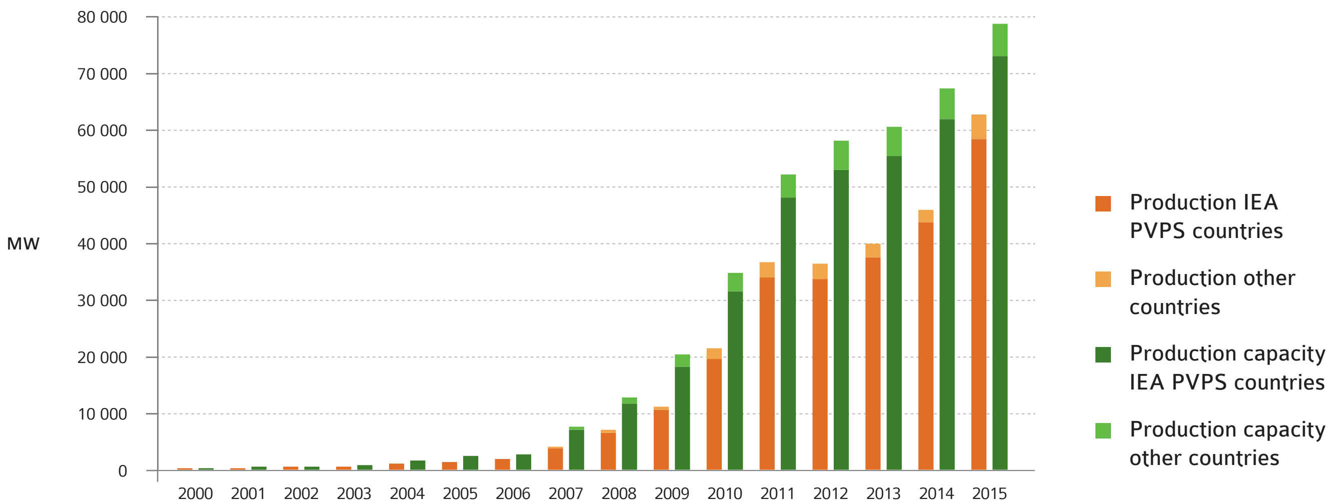
SOURCE IEA PVPS, RTS CORPORATION.

Other IEA PVPS countries producing PV modules in 2015 are Malaysia, Japan, Germany, South Korea and the USA. Australia, Austria, Canada, Mexico, Denmark, France, Italy, Sweden, Thailand and Turkey also have PV module production capacities. Malaysia produced around 3,7 GW of PV modules. South Korea and Japan produced 3,4 GW and 3,1 GW respectively. In Europe, Germany is the largest European PV module producing country with around 2 GW of production. USA manufactured about 1,3 GW of PV modules.

In non-IEA PVPS members, major producing countries are Singapore, Taiwan, the Philippines and India. In addition to these countries, the production bases were established or planned in various countries. In 2015, plans for production were announced in Algeria, Indonesia, Cuba, Brazil, etc.

Thin-film PV modules are mainly produced in Malaysia, Japan, USA, Germany and Italy. The largest thin-film producer is First Solar from the USA. It produced 2,618 MW of CdTe Thin-film PV modules in its factories in the USA and Malaysia in 2015. It ranked in the sixth rank in the global PV module production. It is notable that conversion efficiency of CdTe PV modules has significantly improved. The company achieved 22,1% of conversion efficiency in the laboratory. The second largest thin-film PV manufacturer in

FIGURE 18: YEARLY PV PRODUCTION AND PRODUCTION CAPACITY IN IEA PVPS AND OTHER MAIN MANUFACTURING COUNTRIES 2000-2015 (MW)



SOURCE IEA PVPS, RTS CORPORATION.

THE UPSTREAM PV SECTOR / CONTINUED

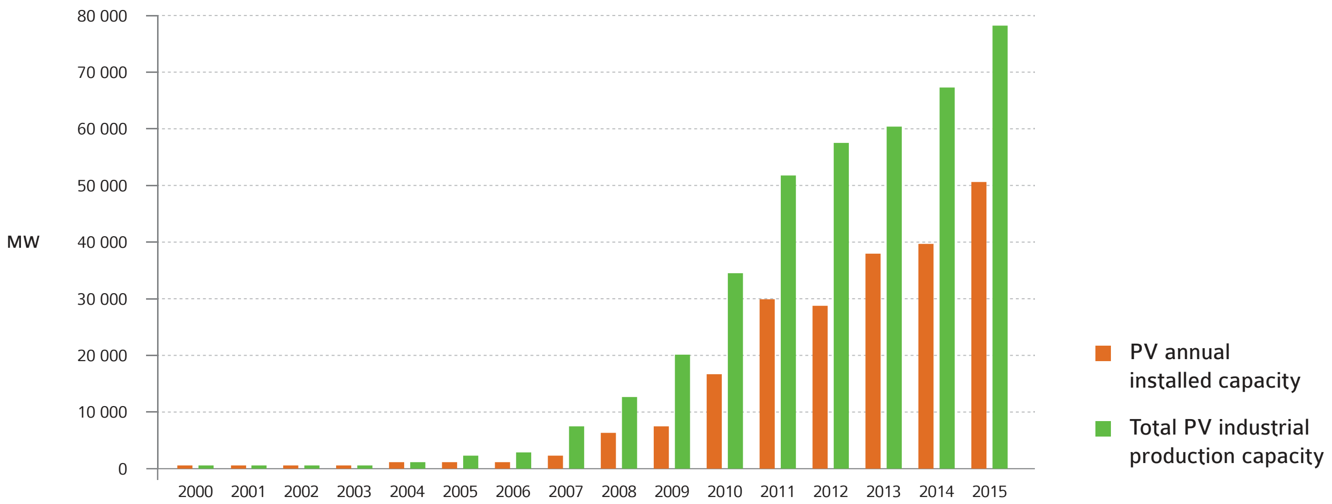
2015 was Solar Frontier from Japan. It produced 860 MW of CIS modules in Japan. Other thin-film manufacturing activities were reported from Germany, Italy, China and Thailand, while production volumes remained relatively small. It is estimated that 3,6 GW of thin film PV modules were produced in 2015, accounting for 6% of total PV module production (see Figure 19). As well as previous years, efforts on R&D and commercialization of CIGS PV modules are continuously reported in a number of IEA PVPS member countries aiming at higher conversion efficiency and higher throughput. Thin-film PV modules using flexible or light-weight substrates are also the focus of R&D efforts for BIPV application.

In 2015, activities on concentrator PV (CPV) cells/modules were 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, USA, France and Spain are active in this area. While conversion efficiency of CPV solar cells has been improving, CPV system seems to less cost competitive to compete with conventional PV systems. In 2015, Soitec in France announced withdrawal from CPV business.

As mentioned before, the capacity utilization ratio was improved in 2015 to around 80%. Most Tier 1 PV module manufacturers have plans for manufacturing capacity enhancement to cope with the expected further growth of the global PV market. Enhancement of manufacturing capacity is not only achieved by building new factories but also by acquiring closed factories or establishing joint ventures with other companies. Some manufactures entered production with new technologies such as PERC (Passivated Emitter Rear Cell) structures, solar cells with multi busbars, etc. As for PV modules, higher wattage products have been released using high efficiency solar cells or half-cut solar cells to reach a higher output. Other new products reported recently are double glass PV modules with 30 years warrantee, PV modules for 1 500 Volt connections, PV modules using bifacial solar cells to gain more yields, light-weight crystalline silicon PV modules using chemical tempered glass, etc.

The average spot price of PV modules moderately decreased in 2015 from 0,6 USD/W in the beginning to 0,56 USD/W in December 2015. It is expected that with lower level of profit, consolidation of PV module manufacturers will be continued as long as capacity exceeds demand.

FIGURE 21: PV INSTALLATIONS AND PV MODULE PRODUCTION CAPACITIES 2000 - 2015 (MW)



SOURCE IEA PVPS, RTS CORPORATION.

WHY PRODUCTION VOLUMES DO NOT MATCH THE INSTALLED CAPACITIES

IEA PVPS tracks down global PV module production volume and installed capacity. It is reasonable to believe that a certain amount of PV modules are stored in warehouses or already installed on new projects that are not connected yet. However, if we sum up each year's production volume and compare it with global cumulative capacities, a huge difference is observed. One explanation of such discrepancies is that in the era of GW level production, outsourcing solar cells or producing PV modules by OEM or ODM contractors has been common for PV manufacturers to address increase in demand, avoid ADs and CVDs, or overcome cost pressures. In that respect, a significant share of PV module production could have been counted twice. This so-called "double counting" has been recognized from the early stage of the PV industry. With the growth of the PV market, the differences between installed capacity and production volume expanded. It is also noted that shipment and production volumes are different. In all cases, the total production numbers look overestimated and should be refined to approach the reality of the PV industry these days.

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	52%
2008	6 600	450	7 050	11 700	1 000	12 700	56%
2009	10 511	750	11 261	18 300	2 000	20 300	55%
2010	19 700	1 700	21 400	31 500	3 300	34 800	61%
2011	34 000	2 600	36 600	48 000	4 000	52 000	70%
2012	33 787	2 700	36 487	53 000	5 000	58 000	63%
2013	37 399	2 470	39 869	55 394	5 100	60 494	66%
2014	43 799	2 166	45 965	61 993	5 266	67 259	68%
2015	58 304	4 360	62 664	72 900	5 800	78 700	80%

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

SOURCE IEA PVPS & OTHERS.

THE UPSTREAM PV SECTOR / CONTINUED

Trade Conflicts

Trade conflicts concerning PV products, including polysilicon, continued to impact business strategies of PV companies. To avoid the duties imposed in several countries for different kinds of products, PV module manufacturers announced new production enhancement plans in Malaysia, Thailand, India, and some European countries. In this section, the trends regarding the major trade conflicts observed in 2015 are described.

In 2015, The US Department of Commerce (DOC) reviewed margins for anti-dumping duty (AD) and countervailing duty (CVD) decided in December 2012. Compared to ADs and CVDs for Chinese PV products as well as ADs for Taiwanese products decided in January 2015 for new investigation started in 2013 to close the loopholes, reviewed AD and CVD margins are lower for most of impacted companies.

The European Commission (EC) and the Chinese PV industry continued to implement an agreement on minimum prices and maximum shipping volume. In that respect, the EC decided to exclude 6 Chinese companies from this agreement for violation in 2015. Those companies will be imposed to AD duties set in June 2013. Trina Solar of China voluntarily withdrew from the agreement because the company established production manufacturing outside of China.

In Australia, the Anti-dumping Committee concluded its anti-dumping investigation started in May 2014. While the Committee confirmed the fact of dumping in April 2015, it did not impose duties because the damage to Australian PV industry was not observed. In 2016, The Committee announced to review the survey results and the outcome remains to be seen.

In July 2015, the Canada Border Services Agency (CBSA) decided to impose ADs and CVDs for an investigation of anti-dumping and unfair subsidy on made-in China PV products.

In September 2015, Indian PV manufacturers appealed to the Department of Commerce for an investigation of anti-dumping related to imported PV products. The Indian Ministry of Finance decided not to impose ADs in August 2014 for PV modules produced in China, Malaysia, USA and Taiwan. The domestic content requirement (DCR) for national PV tender in India is also an issue between the USA and India. The Indian government is appealing WTO's decision that DCR is against the WTO agreement (India's appeal against the WTO ruling was rejected in September 2016).

China has been imposing ADs and CVDs on polysilicon made in USA and Europe and ADs on Korean-made polysilicon since April 2014. In September 2014, China decided to suspend the "processing rules" that allow exemption of import duties for imported materials processed in China for export. Mainly US manufacturers are affected by ADs and CVDs while Korean producers can continue to export to China with lower ADs. Wacker Chemie, a Germany polysilicon producer avoids ADs by the agreement on the price with the Chinese government. REC Silicon of Norway that has manufacturing bases in USA announced it has established a joint venture with Chinese companies to construct a FBR process plant in China.

Balance of System Component Manufacturers and Suppliers

The Balance of system (BOS) component manufacturers are an important part of the PV value chain and are accounting, in some market segments, for an increasing portion of system costs as PV module prices fall. Accordingly, the production of BOS products has become an important sector of the overall PV industry.

Inverter technology is currently the main focus of interest since the penetration ratio of grid-connected PV systems has reached more than 99%. New grid codes require the active contribution of PV inverters to contribute to grid management and grid protection, thus new inverters are currently being developed with sophisticated control and interactive communications features. With the help of these functions, the PV plants can actively support grid management; for example by providing reactive power and other ancillary services.

PV inverters are produced in many IEA PVPS member countries: China, Japan, South Korea, Australia, the USA, Canada, Germany, Spain, Austria, Switzerland, Denmark, France and Italy. Generally, supply structures of PV inverters are much affected by national codes and regulations and national origin so that domestic manufacturers tend to dominate domestic PV markets. This trend is reflected in the rankings of top inverter manufacturers.

However, in some markets where cost reduction pressure is strong, lower priced imported products started increasing their share in terms of shipped capacity. The products dedicated to the residential PV market have typical 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. 4,5 MW products are also available. However, for large utility-scale projects, the adoption of string inverters has been increasing.

Chinese inverter manufacturers delivered more than 22 GW in 2015, increasing their global market share to around 40%. Among all Chinese shipments, 19 GW went to their domestic market and 3 GW were exported. Only one producer (SunGrow) ranked in the top 10 manufacturers in 2011; However, top 10 rankings included 4 Chinese companies in 2015, including Huawei and Sungrow ranked number 1 and 2. This was mainly thanks to their increased domestic PV market.

US companies shipped approximately 5,2 GWac of PV inverters in 2015; approximately 89 % of all US systems installed during the year. In Japan, the market is still dominated by domestic inverter manufacturers (which represent more than 15 companies).

Inverter technologies have been improving with the adoption of new power semiconductor devices such as SiC and GaN. These devices allows higher conversion efficiency and reduction of size resulted in lower LCOE. As well as PV module suppliers, inverter manufacturers have been suffering from the significant cost pressure and tighter competition. The consolidation of manufacturers is still underway and players need to differentiate products. Some companies have started to provide complete solutions including operation and monitoring of PV power plants. It is also observed that manufacturers offer inverters together with a solar storage solution. The Module Level

Electronic (MLE) devices represents a market consisting of micro-inverters and DC optimizers that work for single PV modules. It is expanding, especially in the USA which accounts for more than 70 % of the global market. MLE devices can achieve higher output for PV arrays suffering from shading.

The 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. With the increase of utility-scale PV power plants, the market for single-axis and double-axis trackers has been growing. Almost 50 % of utility-scale PV power plants are now adopting trackers, mostly single-axis ones.

For distributed generation, the launch of packaged products consisting of storage batteries and PV with Home Energy Management Systems (HEMS) or Building Energy Management Systems (BEMS) has been announced. Especially the attention for storage batteries is growing with the development of self-consumption-based business models and tighter codes for building energy efficiency. In the regional markets that already achieved high penetration of PV such as California, Hawaii, Australia, the demand for storage batteries for PV systems is increasing. However, storage batteries are still expensive without subsidies and the market remains small compared to the PV market.

THE DOWNSTREAM PV SECTOR (THE DEVELOPERS AND OPERATORS)

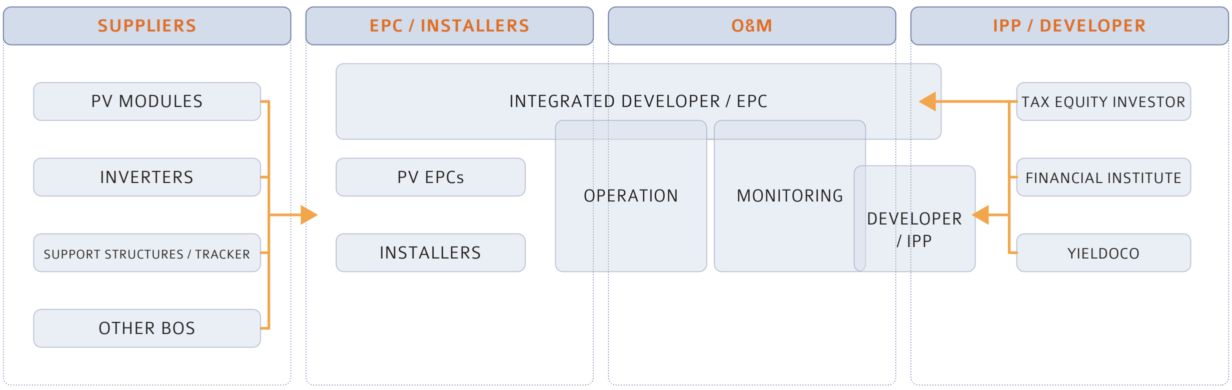
In the PV industry, the downstream PV sector is the one that develops, maintain and operates PV plants. An overview of the downstream part of the PV sector is described in Figure 22 (example for utility scale projects).

Specialized PV developers have been active in PV power plant development in the countries where feed-in tariff programs are implemented or power purchase agreements (PPA) are guaranteed. These players have diverse origins: subsidiary of utility companies, subsidiary of PV module or PV material companies, companies involved in conventional or oil-related energy business and pure-players. While some developers sell PV power plants to some so-called independent power providers or investors, some other developers own PV plants as their own assets. EPCs are installers that provide engineering, procure components such as PV modules and inverters from suppliers and integrating them into PV systems or PV power plants. Among the companies owning PV power plants as power generation assets, the so-called "YieldCos" attracted attention in 2014 and 2015 because some of them succeeded in raising money through IPOs. YieldCos can be seen as rather specialized SPVs that own and operates PV power generation and provide stable cash flow for investors. In the USA, several YieldCos are listed in the stock market: for instance 8point3 Energy Partners raised 420 MUSD in June 2015 and TerraForm Global raised 675 MUSD in July 2015. While most YieldCos experience lower share prices than expectation in 2016, the trading of the utility-scale PV projects (the so-called "secondary market") has been more and more active with these downstream players.

Companies providing Engineering, Procurement and Construction for PV systems (mainly in the utility-scale segment but also for large commercial or industrial applications) are called EPCs. EPCs include pure PV companies and general construction companies offering services for installing PV systems. Integrated PV developers sometimes conduct EPC services themselves. With the growth of market, operation and maintenance (O&M) of PV system became more and more important and O&M business is poised to grow significantly with the development of the market.

Several integrated companies are active in the downstream sector. Those companies produce PV modules or polysilicon, develop PV projects, while providing EPCs and O&M services. Tax equity investors or other financial institutions also play an important role in PV project development as investors or loan providers. Companies financing or developing PV projects through crowd financing are reported. Financing options in specific countries are reported in National Survey Reports.

FIGURE 22: OVERVIEW OF DOWNSTREAM SECTOR (UTILITY PV APPLICATION)



SOURCE IEA PVPS & OTHERS.

TRENDS IN PHOTOVOLTAIC APPLICATIONS // 2016

PHOTOVOLTAIC POWER SYSTEMS PROGRAMME WWW.IEA-PVPS.ORG

TOTAL SPENDING IN PV SECTOR IN 2015 (CAPEX AND OPEX)

$100 BILLION

TOP 5 PV MARKET IN 2015

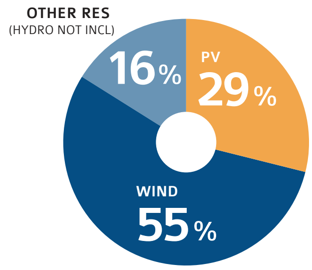
CHINA	15,2 GW
JAPAN	10,8 GW
USA	7,3 GW
UK	4,1 GW
INDIA	2,1 GW

PV CONTRIBUTION TO ELECTRICITY DEMAND & SAVING CO_2 EMISSION

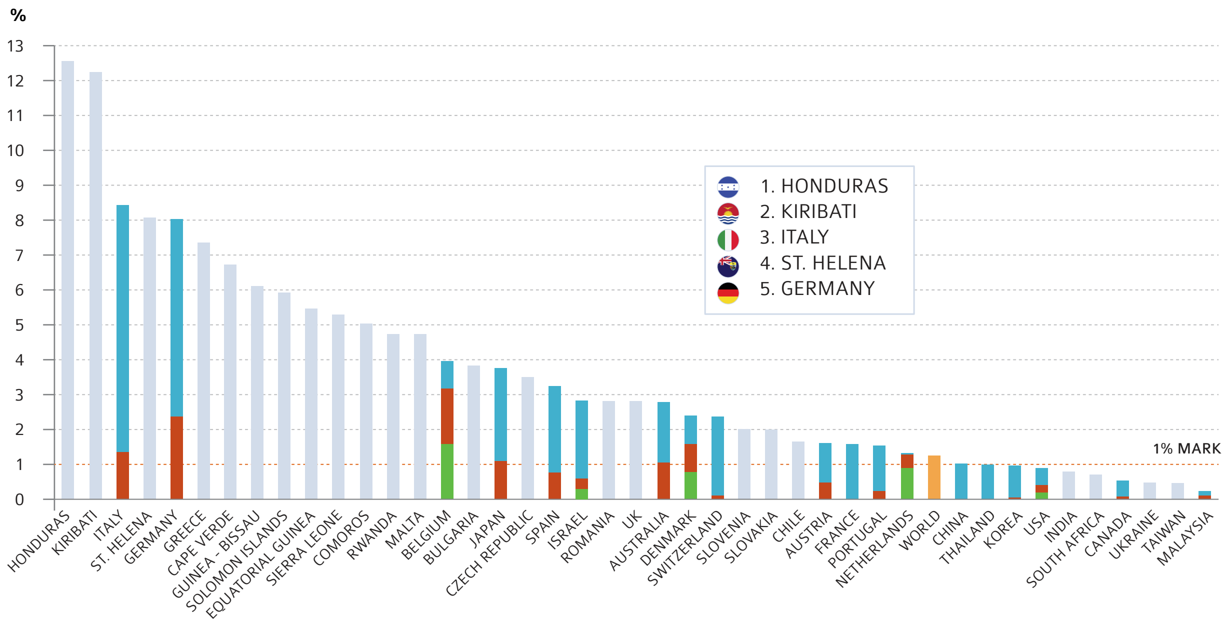
1,2 %
Share of PV in the global electricitiy demand in 2015

166m
millions of tons of CO_2 **saving** every year

SHARE OF PV IN THE TOTAL RES INSTALLED CAPACITY IN 2015



PV CONTRIBUTION TO THE ELECTRICITY DEMAND IN 2015



- Self-consumed electricity
- Self-consumed electricity under net-metering
- PV electricity injected into the grid for IEA PVPS countries
- Total PV electricity production for other countries
- PV in % of the world electricity demand

THE MOST COMPETITIVE TENDERS IN THE WORLD

UNTIL Q3 2016 // USD/MWh

CHILE	29,1
UNITED ARAB EMIRATES	29,9
MEXICO	35,5
PERU	49
UNITED ARAB EMIRATES	58
JORDAN	61
SOUTH AFRICA	65
CHILE	65
INDIA	67

228 GW
global PV capacity end of 2015

50,7 GW
commissioned in 2015

With more than 50 GW connected to the grid in 2015, PV continues to prove its ability to significantly contribute to the decarbonization of the power sector. High penetration shares are common and were reached in a few years, at a decreasing cost.

PV CONTINUES ITS IMPRESSIVE AND DYNAMIC DEVELOPMENT IN TECHNOLOGY, INDUSTRY, APPLICATIONS, INSTALLED CAPACITY, PRICE AND BUSINESS MODELS, PROVIDING GREAT OPPORTUNITIES FOR MANY STAKEHOLDERS ALONG THE VALUE CHAIN.

STEFAN NOWAK

PV cells laminated to a skylight. © Lawrence Berkeley National Lab

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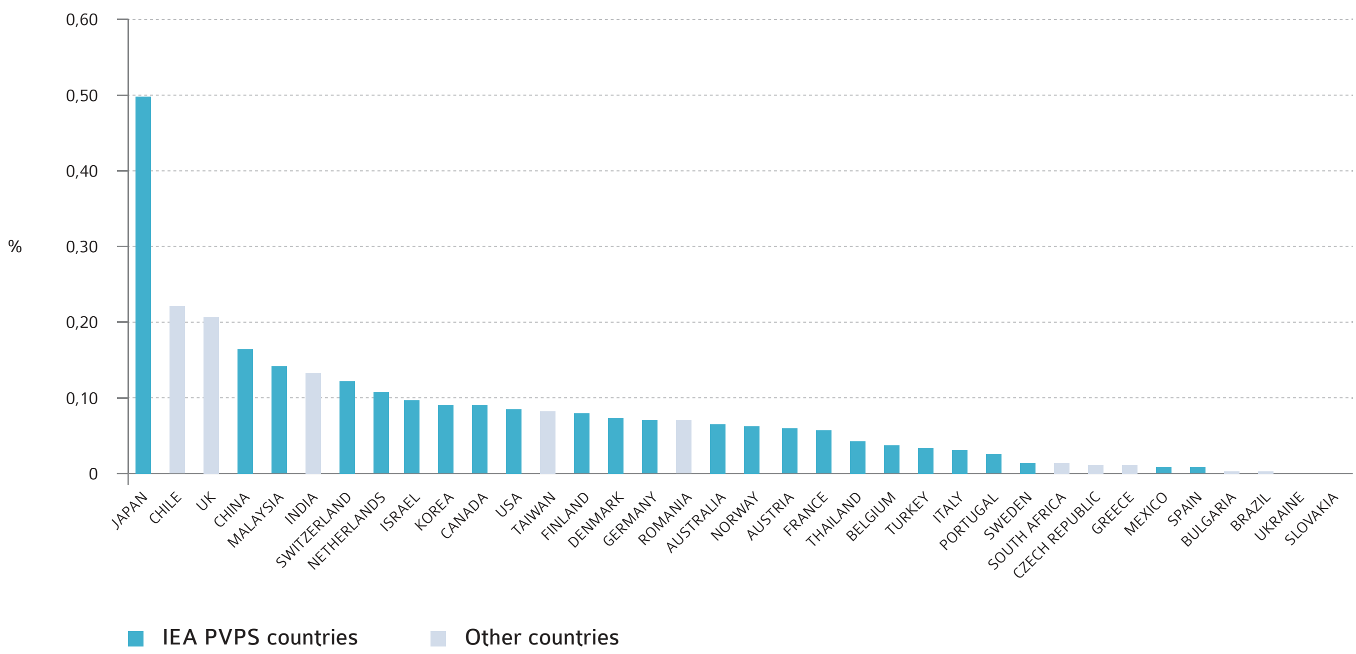
PV AND THE ECONOMY

VALUE FOR THE ECONOMY

The 20% growth of the PV installations between 2014 and 2015 and decline in prices, especially for utility-scale plants caused the business value of PV to remain at a similar level as in previous years at approximately 80 BUSD.

Figure 23 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 23: BUSINESS VALUE OF THE PV MARKET COMPARED TO GDP IN % IN 2015



SOURCE IEA PVPS & OTHERS.

VALUE FOR THE ECONOMY / CONTINUED

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.

As stark examples, Australia and Japan are net importers. Last year, Australia's import balance was over 1 287 MAUD while Japan's net import export balance value was around 277 MJPY. On the other hand, Norway was able to increase its PV market value with over 1,8 BNOK export in 2015. In the case of Switzerland, following the trend in 2014, the balance was highly positive. In fact, 360 MCHF of exports compensated some 230 MCHF of 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 20 BUSD per year.

CONTRIBUTION TO THE GDP

The business value of PV should be compared to the GDP of each country. In 2015, the business value of PV represents less than 0,5% in all countries considered, as can be noticed in Figure 23. The PV business value in Japan in 2015 represented 0,50% of the country GDP, down from 0,56% in 2014, up from 0,23% in 2013. Japan is then followed by two booming PV markets last year, Chile and United Kingdom, for which the PV business covered in 2015 were 0,22% and 0,21% of their GDP respectively.

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 2015 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 7: EMPLOYMENT IN IEA PVPS REPORTING COUNTRIES

COUNTRY	LABOUR PLACES	DIFFERENCE WITH 2014	
USA	208 859	20%	↑
JAPAN	128 900	2%	=
MALAYSIA	21 717	89%	↑
AUSTRALIA	14 620	0%	=
FRANCE	8 300	-12%	↓
CANADA	8 100	0%	=
SWITZERLAND	5 700	-2%	=
SPAIN	5 000	-33%	↓
AUSTRIA	2 936	-9%	↓
NORWAY	966	25%	↑
SWEDEN	830	15%	↑

SOURCE IEA PVPS.

18kW PV system at Shoreline Community College. © Northwest Seed

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COMPETITIVENESS OF PV ELECTRICITY IN 2015

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 2015, the lowest system prices in the off-grid sector, irrespective of the type of application, typically ranged from about 2 USD/W to 20 USD/W. The large range of reported prices in Table 8 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 2015 also varied between countries as shown in Table 8. 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 2015, through a decrease in module prices, balance of system, soft costs and margins, but the highest prices went down faster than the lowest ones, again. However, system prices significantly below 1 USD/Wp for large-scale PV systems are 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. However, local labour costs have a strong influence on final system prices with differences observed that could reach at least 0,1 USD/Wp and more. Prices for small rooftops, especially in the residential segment continued to decline in 2015 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, even if they declined substantially in 2015.

SYSTEM PRICES / CONTINUED

TABLE 8: INDICATIVE INSTALLED SYSTEM PRICES IN CERTAIN IEA PVPS REPORTING COUNTRIES IN 2015

	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	6,75 - 11,26	7,50 - 11,00	5,63 - 8,26	2,37	1,78	1,78	1,34	NA	-	2,18	1,64
AUSTRIA	5,00	5,55	5,00	5,55	1,66	1,84	1,27	1,41	1,00	1,11	NA	-
BELGIUM	NA	-	NA	-	1,50 - 1,90	1,66 - 2,11	1,20 - 1,50	1,33 - 1,66	1,20 - 1,40	1,33 - 1,55	NA	-
CANADA	NA	-	NA	-	3,60	2,81	2,90	2,27	2,20	1,72	2,00 - 2,60	1,56 - 2,03
CHINA	NA	-	NA	-	6,00 - 7,00	0,95 - 1,11	6,00 - 7,00	0,95 - 1,11	NA	-	7,00 - 8,00	1,11 - 1,27
DENMARK	15 - 30	2,23 - 4,46	20 - 45	2,97 - 6,69	10 - 18	1,48 - 2,68	9,00 - 16,00	1,34 - 2,38	8,00 - 13,00	1,19 - 1,93	5,00 - 9,00	0,74 - 1,34
FINLAND	5,00	5,55	3,50	3,88	1,45 - 1,75	1,61 - 1,94	1,15 - 1,40	1,28 - 1,55	1,05 - 1,35	1,16 - 1,50	1,10 - 1,30	1,22 - 1,44
FRANCE	NA	-	NA	-	2,40 - 3,00	2,66 - 3,33	1,50 - 2,30	1,66 - 2,55	NA	-	0,90 - 1,30	1,00 - 1,44
GERMANY	NA	-	NA	-	1,30 - 1,70	1,44 - 1,89	1,00 - 1,30	1,11 - 1,44	NA	-	< 1,00	< 1,11
ITALY*	NA	-	NA	-	1,45 - 1,89	1,93 - 2,52	NA	-	NA	-	0,92 - 1,14	1,23 - 1,52
JAPAN	NA	-	NA	-	348	2,87	256	2,11	NA	-	240	1,98
KOREA	NA	-	NA	-	1 500 - 2 000	1,32 - 1,77	2 200 - 2 300	1,94 - 2,03	NA	-	NA	-
MALAYSIA	NA	-	NA	-	7,79	1,99	6,83	1,75	6,92	1,77	NA	-
NORWAY	60 - 100	7,44 - 12,40	70 - 150	8,68 - 18,59	18	2,23	15	1,86	13	1,61	NA	-
PORTUGAL	3,00	3,33	2,7	2,99	2,20	2,44	1,40	1,55	1,00	1,11	0,70 - 0,80	0,78 - 0,89
SPAIN	2,50 - 3,00	2,77 - 3,33	2,00 - 2,80	2,22 - 3,11	1,40 - 1,50	1,55 - 1,66	0,80 - 1,20	0,89 - 1,33	NA	-	NA	-
SWEDEN	25,00	2,96	20,10	2,38	15,00	1,78	12,70	1,51	11,80	1,40	10,30	1,22
SWITZERLAND	6,00 - 15,00	6,23 - 15,59	4,00 - 12,00	4,16 - 12,48	2,50 - 4,00	2,60 - 4,16	1,50 - 3,00	1,56 - 3,12	1,30 - 1,80	1,35 - 1,87	NA	-
THAILAND	195 - 210	5,69 - 6,13	195 - 210	5,69 - 6,13	60 - 75	1,75 - 2,12	50 - 55	1,45 - 1,61	50 - 55	1,45 - 1,61	41 - 54	1,12 - 1,58
USA	NA	-	NA	-	3,50	3,50	NA	-	2,03	2,03	1,33 - 1,54	1,33 - 1,54

NOTE: DATA REPORTED IN THIS TABLE DO NOT INCLUDE VAT.
*: DATA FROM NSR 2014.

SOURCE IEA PVPS.

MODULE PRICES

On average, the price of PV modules in 2015 (shown in Table 9) accounted for approximately between 40% and 50% of the lowest achievable prices that have been reported for grid-connected systems. In 2015, the lowest price of modules in the reporting countries was about 0,6 USD/W registered in China and in other countries. However, module prices for utility-scale plants have been reported below these average values, down to 0,45 USD/Wp at the end of 2015. In 2016, these prices continued to go down, pushed by overcapacities and lower market expectations.

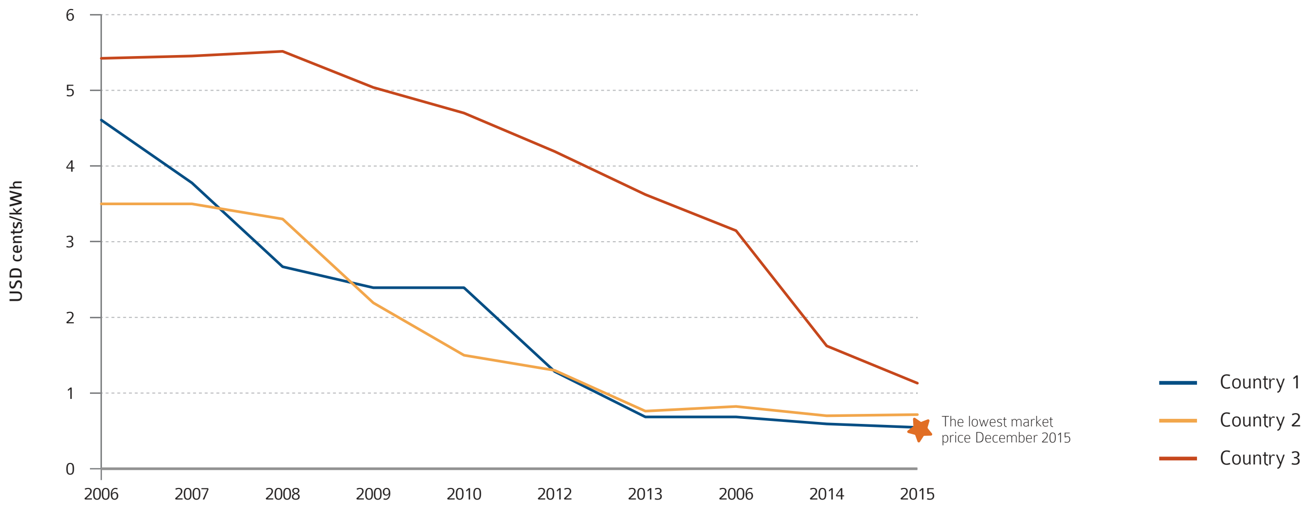
TABLE 9: INDICATIVE MODULE PRICES (NATIONAL CURRENCY/WATT AND USD/WATT) IN SELECTED REPORTING COUNTRIES

COUNTRY	CURRENCY	LOCAL CURRENCY/W	USD/W
AUSTRALIA	AUD	0,8	0,6
AUSTRIA	EUR	0,56 - 0,6	0,62 - 0,67
CANADA	CAD	0,80	0,63
CHINA	CNY	3,60	0,57
DENMARK	DKK	3 - 7	0,45 - 1,04
FINLAND	EUR	0,65	0,72
FRANCE	EUR	0,57 - 0,62	0,63 - 0,69
GERMANY	EUR	0,47 - 0,64	0,52 - 0,71
ITALY*	EUR	0,55	0,61
JAPAN	JPY	138	1,14
KOREA	KRW	974	0,86
MALAYSIA	MYR	3,07	0,79
SPAIN	EUR	0,6	0,67
SWEDEN	SEK	7,6	0,9
SWITZERLAND	CHF	0,70	0,73
THAILAND	THB	25 - 40	0,73 - 1,17
USA	USD	0,72	0,72

NOTES: DATA REPORTED IN THIS TABLE DO NOT INCLUDE VAT.
GREEN = LOWEST PRICE. RED = HIGHEST PRICE.
*: DATA FROM NSR 2014.

SOURCE IEA PVPS.

FIGURE 24: EVOLUTION OF PV MODULES PRICES IN 3 INDICATIVE COUNTRIES IN USD CENTS/KWh

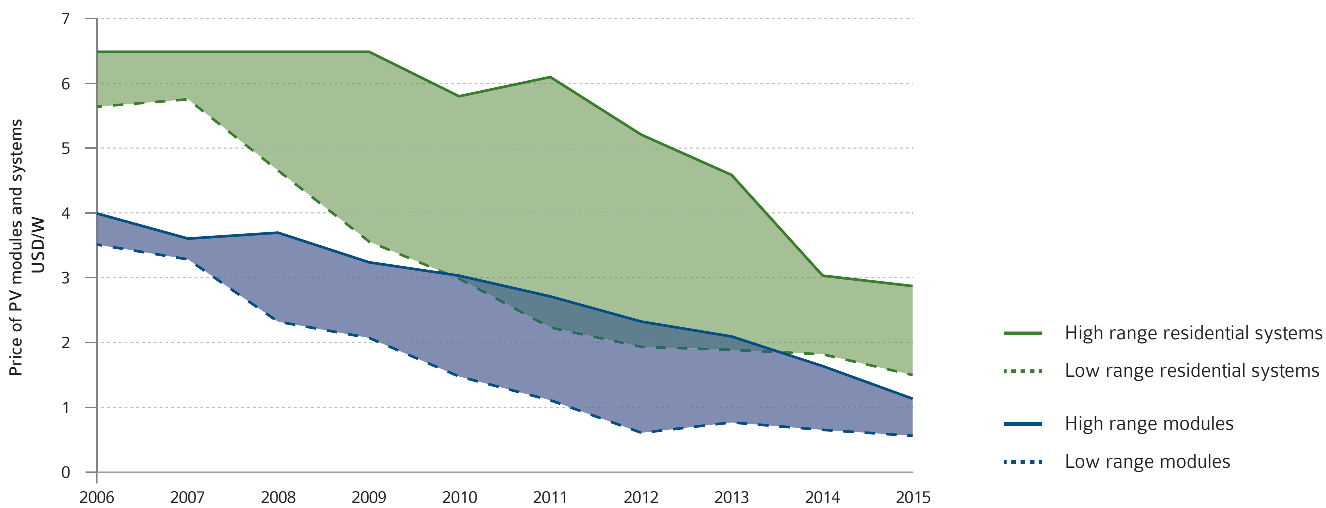


SOURCE IEA PVPS & OTHERS.

The production costs for modules continued to decline as well, with several tier 1 module manufacturers reporting at the end of 2015 production costs around 0,4 USD/Wp and declining, with some possibilities to reach the 0,3 USD/Wp threshold by the end of 2017.

After having experienced prices so low that many companies lost money in 2012 and 2013, PV modules prices decreased slightly in 2014 and again in 2015. Figure 24 shows the evolution of prices for PV modules in selected key markets. Figure 25 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 25: EVOLUTION OF PV MODULES AND SMALL-SCALE SYSTEMS PRICES IN SELECTED REPORTING COUNTRIES 2006 - 2015 USD/W



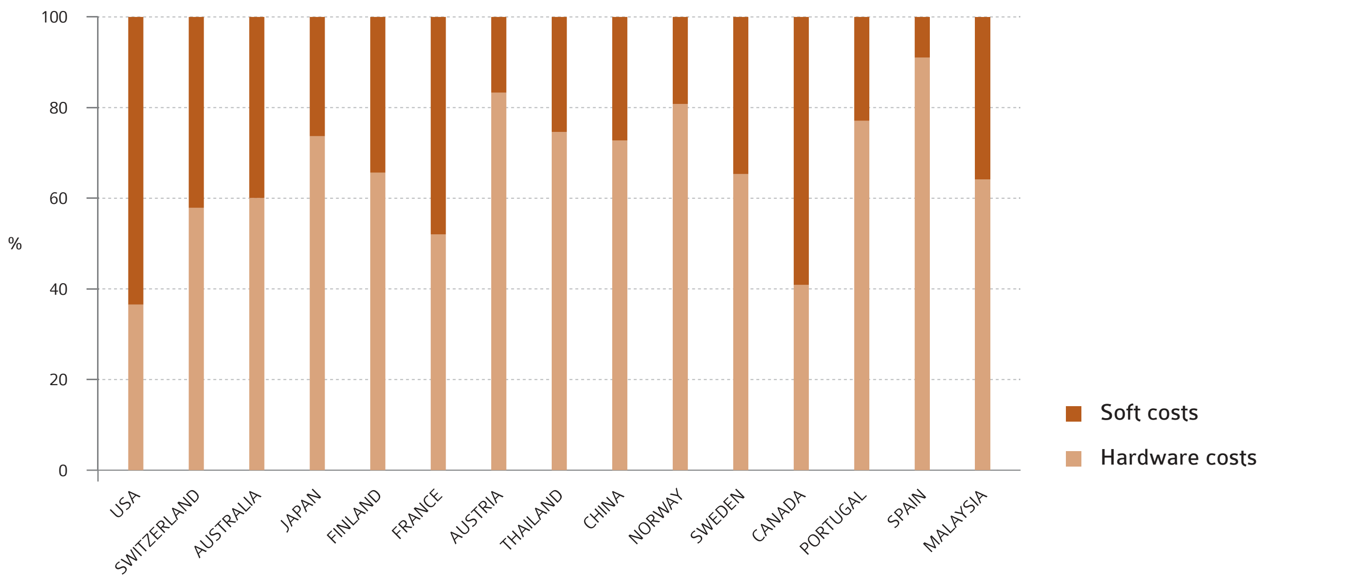
SOURCE IEA PVPS & OTHERS.

SYSTEM PRICES / CONTINUED

System prices for residential PV systems reveal huge discrepancies from one country to another. In particular the final price of modules as seen above but also the other price components, such as the inverter, the rest of the BoS and the installation costs.

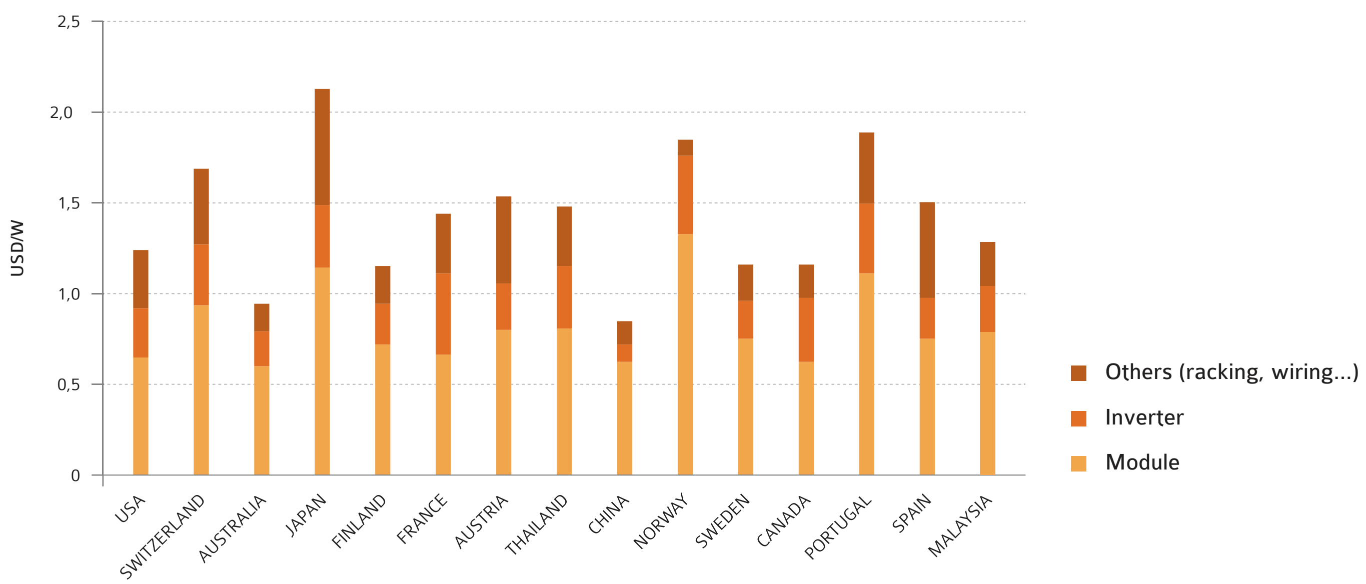
The following figures illustrate such differences which in general might be explained by the local regulations, the size of the market and the market segmentation which can be diverse.

FIGURE 26: AVERAGE COST BREAKDOWN FOR A RESIDENTIAL PV SYSTEM < 10KW



SOURCE IEA PVPS.

FIGURE 27: RESIDENTIAL SYSTEM HARDWARE COST BREAKDOWN



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 when it has been produced by PV and locally consumed.

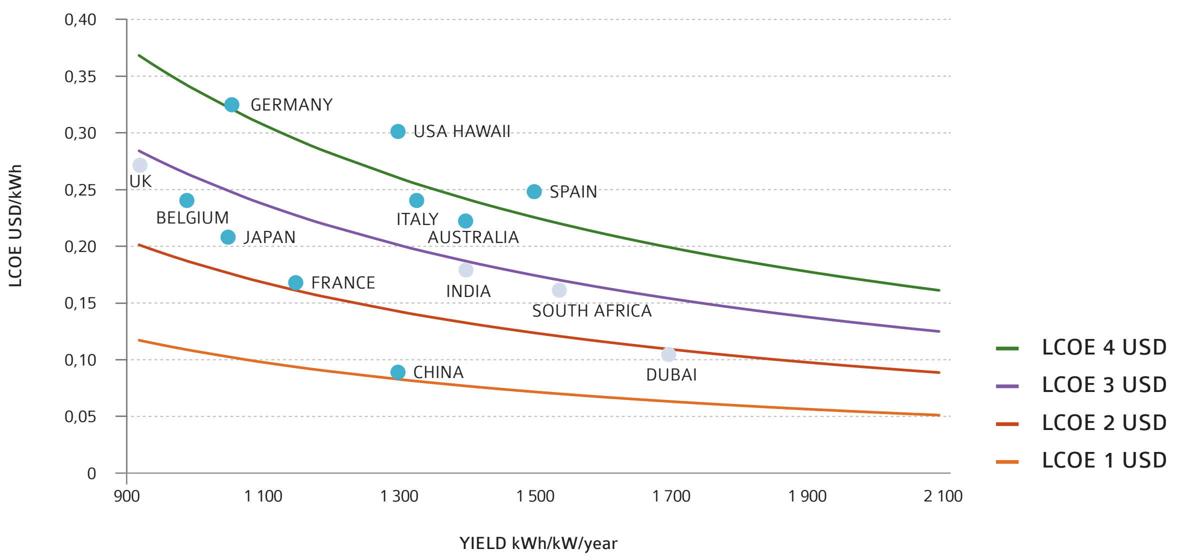
However, it is assumed that the level of self-consumption that can be achieved with a system that provides on a yearly basis up to the same amount of electricity as the local annual electricity consumption, varies between less than 30% (residential applications) and 100% (for some industrial applications)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

FIGURE 28: 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 & OTHERS.

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;
- Levies (used among other things to finance the FiT for renewables).

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 2015

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 2015 and in the first months of 2016. 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 moment of writing these lines, the record was 2,41 USDcents/kWh for a PV project in Abu Dhabi, under specific conditions. This project won the bid proposed by local authorities but has not yet been built. Many other winning bids globally reached a level between 3 and 6 USDcents/kWh. Lower PPAs were granted in 2015 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.

Aerial view showing shading of the 850 kW PV system at the U.S. Coast Guard Petaluma Site. © U.S. Coast Guard

seven

PV IN THE ENERGY 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.

Some small countries have taken the lead of the highest PV penetration. The speed at which PV can be deployed has pushed Honduras above the 12% penetration mark in only one year. Penetrations between 4 and 12% are also common in several islands and countries with low energy demand, such as Rwanda or the Kiribati islands but such cases are exceptions.

Italy remains the number one country in the IEA PVPS network with 8,4% of its electricity that will come from PV in 2016 based on 2015 installations. The increase of that percentage in 2015 compared to 2014 comes from a small increase of the capacities and a decrease of the consumption. This number can be translated into 16% to 17% of the peak electricity demand. In Germany, with almost 8%, the 39,7 GW installed in the country produce up to 50% of the instantaneous power demand on some days, and around 14% of the electricity during the peak periods.

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

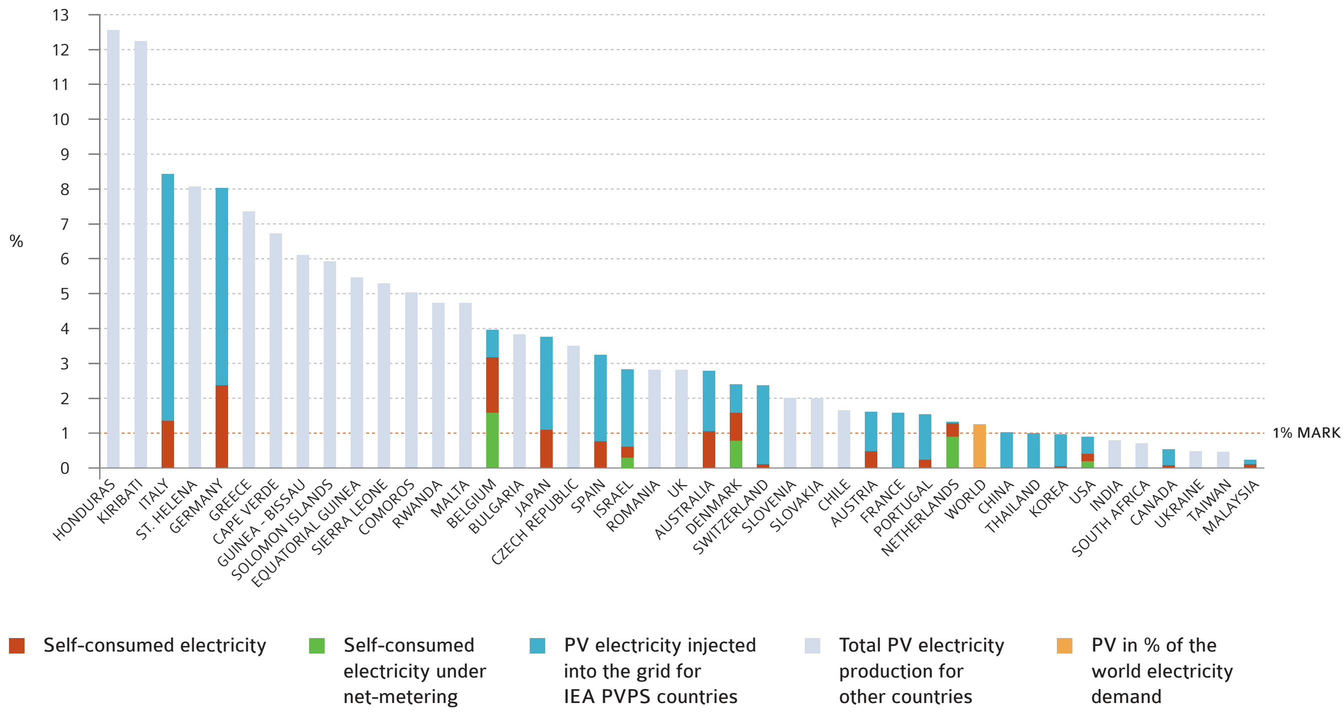
- Estimated PV installed and commissioned capacity on 31.12.2015.
- Average theoretical PV production in the capital city of the country (using solar irradiation databases: JRC's PVGIS, SolarGIS, NREL's PVWATT or, when available, country data).
- Electricity demand in the country based on the latest available data.

Three countries outside the IEA PVPS network have the ability to produce more than 3% of their electricity demand: Greece (around 7,4% based on the 2015 installed capacity), Bulgaria and the Czech Republic. Japan has reached the 3,8 % mark, a remarkable level in a country with a modern economy. Spain remains below the 4% mark as well as Belgium, which is producing 3,9% of its electricity thanks to PV.

Romania, Australia, Slovenia and Israel are above the 2% mark, together with Switzerland, Denmark and the UK. Austria, France, Portugal and Chile are still below the 1,5 % mark. In China in 2016, 1% of the electricity demand will be now covered by PV for the first year. Many other countries have lower production numbers, but in total 35 countries will produce at least 1% of their electricity demand from PV in 2016.

PV ELECTRICITY PRODUCTION / CONTINUED

FIGURE 29: PV CONTRIBUTION TO THE ELECTRICITY DEMAND IN 2015



SOURCE SOURCE IEA PVPS & OTHERS.

Figure 29 shows how PV theoretically contributes to the electricity demand in IEA PVPS countries, based on the PV base at the end of 2015.

GLOBAL PV ELECTRICITY PRODUCTION

With around 228 GW installed all over the world, PV could produce around 281 TWh of electricity on a yearly basis. With the world's electricity consumption above 22 000 TWh in 2015, this represents slightly more than 1,2 % of the electricity global demand covered by PV.

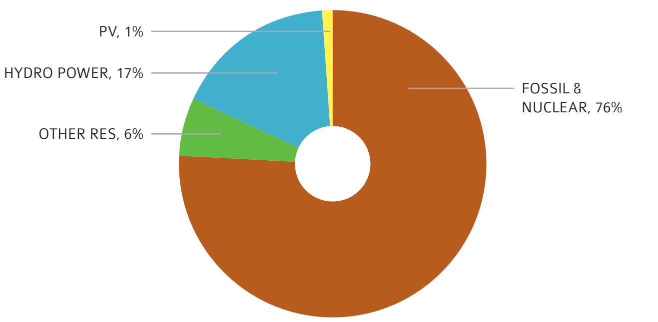
Figures 30 and 31 compare this number to other electricity sources, and especially renewables.

PV represents 29% of the world's installed capacity of renewables, excluding hydropower. In the last fifteen years in the European Union, PV's installed capacity ranked third with 98 GW installed, after gas (120 GW) and wind (137 GW), ahead of all other electricity sources, while conventional coal and nuclear were decommissioned.

The trend is not so different outside Europe and the speed of transformation increases. In China, PV represented 10% of the new capacity installed in the country in 2015. In fact, China installed 146 GW of new power generation capacity, up from 103 GW in 2014 and reached 100% of electrification in 2015.

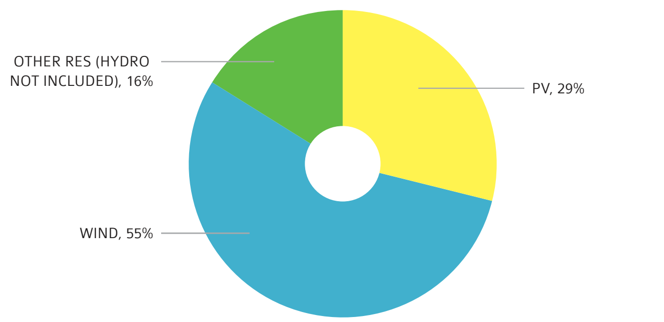
In 2015, Japan installed more PV capacities than all other technologies together and experienced a significant decrease in nuclear power capacities. In the USA renewables represented 15 out of 21 GW, including the PV installations. In Australia, 1,44 GW of power generation capacity was installed in 2014, out of which 63% were PV systems. Korea installed 4,4 GW of new production capacities but renewable additions came mainly from PV with 1 GW out of 1,2 GW installed. In Thailand, out of 6,2 GW of new capacities, 3,5 GW came from renewables.

FIGURE 30: SHARE OF PV IN THE GLOBAL ELECTRICITY DEMAND IN 2015



SOURCE REN21, IEA PVPS.

FIGURE 31: SHARE OF PV IN THE TOTAL RES INSTALLED CAPACITY IN 2015



SOURCE REN21, IEA PVPS.

TABLE 10: PV ELECTRICITY STATISTICS IN IEA PVPS REPORTING COUNTRIES 2015

COUNTRY	FINAL ELECTRICITY CONSUMPTION 2015 (TWh)	HABITANTS 2015 (MILLION)	GDP 2015 (BILLION USD)	SURFACE (km^2)	AVERAGE IRRADIATION kWh/kWp	PV INSTALLATIONS IN 2015 (MW)	PV CUMULATIVE INSTALLED CAPACITY 2015 (MW)	PV ELECTRICITY PRODUCTION (TWh)	2015 INSTALLATIONS PER HABITANT (W/Hab)	CAPACITY PER HABITANT (W/Hab)	CAPACITY PER KM^2 (kW/km^2)	PV PENETRATION (%)
AUSTRALIA	248	24	1 340	7 741 220	1 400	1 022	5 109	7,2	42,9	214,7	0,7	2,9%
AUSTRIA	60	9	374	83 879	1 027	152	937	1,0	17,7	109,3	11,2	1,6%
BELGIUM	82	11	454	30 530	990	97	3 250	3,2	8,6	287,6	106,4	3,9%
CANADA	557	36	1 551	9 984 670	1 150	675	2 579	3,0	18,8	71,9	0,3	0,5%
CHINA	5 550	1 371	10 866	9 562 911	1 300	15 150	43 530	56,6	11,1	31,8	4,6	1,0%
DENMARK	31	6	295	43 090	950	181	787	0,7	32,4	140,5	18,3	2,4%
FINLAND	83	6	230	338 420	838	5	13	0,0	0,9	2,5	0,0	0,0%
FRANCE	476	67	2 422	549 087	1 150	887	6 589	7,2	13,3	99,1	12,0	1,6%
GERMANY	521	81	3 356	357 170	1 055	1 461	39 710	41,9	18,0	490,7	111,2	8,0%
ISRAEL	55	8	296	22 070	1 750	205	886	2	24,6	106,1	40,1	2,8%
ITALY	297	61	1 815	301 340	1 326	300	18 906	25	4,9	311,1	62,7	8,4%
JAPAN	953	127	4 123	377 972	1 050	10 811	34 150	36	85,1	268,7	90,4	3,8%
KOREA	484	51	1 378	100 266	1 314	1 011	3 493	5	20,0	69,0	34,8	0,9%
MALAYSIA	137	30	296	330 800	1 200	27	230	0	2,1	7,6	0,7	0,2%
MEXICO	261	127	1 144	1 964 380	1 780	56	170	0	0,5	1,3	0,1	0,1%
NETHERLANDS	113	17	753	41 500	950	437	1 560	2	25,8	92,2	37,6	1,3%
NORWAY	129	5	388	385 178	800	2	15	0	0,5	2,9	0,0	0,0%
PORTUGAL	51	10	199	92 220	1 700	49	465	1	4,7	44,9	5,0	1,6%
SPAIN	263	47	1 199	505 940	1 500	54	5 430	8	1,2	116,9	10,7	3,1%
SWEDEN	145	10	493	447 420	950	47	127	0	4,9	13,0	0,3	0,1%
SWITZERLAND	58	8	665	41 285	1 000	333	1 394	1	40,3	168,7	33,8	2,4%
THAILAND	175	66	395	513 120	1 226	121	1 420	1,7	1,8	21,5	2,8	1,0%
TURKEY	214	77	718	783 560	1 527	208	266	0,4	2,7	3,5	0,3	0,2%
USA	4 087	323	17 947	9 831 510	1 400	7 283	25 600	35,8	22,5	79,3	2,6	0,9%
WORLD	22 798	7 343	73 434	134 325 435	1 250	50 655	227 822	284,8	7	31	1,7	1,2%

SOURCE SOURCE IEA PVPS & OTHERS.

ELECTRIC 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 close to 7% 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 2016 RWE decided to opt for the same strategy. Other utilities such as MVV are starting to propose PV and storage-based services. 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. End 2015, EDF-EN owned close to 1 GW of PV systems in various countries. 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 less than 100 MW of PV modules for in-house projects. 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 and its subsidiary in Belgium starts to propose PV services for rooftop applications. Total, the French oil and gas giant, has acquired SunPower and has integrated solar in its communication.

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 2015, EGP had more than 400 MW of PV power plants in operation and much more in development. 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, using it for in-house projects.

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 China, most utilities are involved in solar development one way or another. Among the big five utilities, PV production used to be a part of the business until the production boomed in the last years, making investments for additional capacities more important.

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 – GROWTH AND CHALLENGES

The year 2015 experienced a significant growth of the PV market and confirmed the Asian leadership on the PV market and industry. PV has entered rapidly into a new era where the PV market concentrates in countries with energy needs and ad hoc policies. Two of the top three markets in 2015 were located in Asia (China and Japan), followed by Europe as a whole and the USA market. India and many emerging markets can be considered as the fastest growing part of the market.

This trend should be confirmed again in 2016, with Asia consolidating the core of the PV market, and bringing some additional growth, 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, with various patterns. It is important to note that new markets spots have popped up in many places around the world, from the Philippines to Abu Dhabi and Jordan or Brazil, confirming the globalization trends.

In Asia, next to China and Japan, Thailand, Korea, Taiwan, Vietnam, the Philippines and many other countries are starting or continuing to develop. India will most probably soon become the fifth pole of PV development, if the plans to install 100 GW in the coming years are leading to enough installations to be achieved, especially in the distributed segments. 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 2015.

The price decrease that has been experienced in the last years restarted in 2015 and the second quarter of 2016. It has brought several countries and market segments close to a certain level of competitiveness. This is true in countries 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. However, the distributed segments experience difficulties in many countries, due to the difficulties to set-up sometimes complex regulations for self-consumption. In that respect, the absolute market size for distributed PV applications remained roughly stable from 2011 to 2015 while the utility-scale market boomed significantly. 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, even if super-low prices cannot be always considered as competitive. 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 now up to 2 000 MW. 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 deliver electricity to 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 21st 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 and become the major source of electricity in the world.

ANNEXES

ANNEX 1: CUMULATIVE INSTALLED PV CAPACITY (MW) FROM 1992 TO 2015

COUNTRY	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
IEA PVPS COUNTRIES																								
AUSTRALIA	7,4	8,9	10,7	12,8	15,9	18,9	22,6	25,3	29,2	33,6	39,2	45,7	52,3	60,7	70,4	82,4	104,6	187,6	570,9	1376,9	2415,1	3226,0	4087,6	5109,3
AUSTRIA	0	0	0	0	0	0	0	0	0	0	0	0	21,1	24,0	25,6	28,7	32,4	52,6	95,5	187,2	262,9	626,0	785,3	937,1
BELGIUM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23,6	108,5	647,9	1065,6	2105,4	2799,5	3058,3	3152,7	3249,9
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	2579,4
CHINA	0	0	0	0	0	0	0	0	69,2	73,7	92,2	102,3	112,3	120,2	130,2	150,2	190,2	350,2	850,2	3550,2	6750,2	17740,2	28380,2	43530,2
DENMARK	0	0	0	0	0	0	0	0	0	0	0	0	0	2,7	2,9	3,1	3,2	4,6	7,1	16,7	407,7	563,3	605,6	787,0
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	13,4
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	37,5	75,5	179,9	371,2	1209,3	2973,4	4093,6	4747,7	5701,8	6589,2
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	39710,5
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	680,7	885,7
ITALY	8,5	12,1	14,1	15,8	16,0	16,7	17,7	18,5	19,0	20,0	22,0	26,0	30,7	37,5	50,0	120,2	458,3	1181,7	3503,7	12808,3	16455,7	18202,2	18605,7	18905,7
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	6631,7	13599,2	23339,1	34150,5
KOREA	0	0	0	0	0	0	0	0	0	0	5,4	6,0	8,5	13,5	35,8	81,2	356,9	523,7	650,3	729,2	1024,3	1555,0	2481,3	3492,8
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	31,6	138,6	203,7	230,5
MEXICO	0	0	8,8	9,2	10,0	11,0	12,0	12,9	13,9	13,9	13,9	13,9	15,9	16,9	17,9	18,9	19,9	24,9	28,9	29,9	34,9	65,9	114,1	170,1
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	1559,8
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	15,3
PORTUGAL	0	0	0	0	0	0	0	0	0	0	0	2,0	2,0	2,0	4,0	15,0	62,0	110,0	134,0	175,0	244,0	299,0	416,0	465,0
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	5430,4
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	126,8
SWITZERLAND	4,7	5,8	6,7	7,5	8,4	9,7	11,5	13,4	15,3	17,6	19,5	21,0	23,1	27,1	29,7	36,2	47,9	73,6	110,8	210,9	437,2	756,2	1061,2	1394,2
THAILAND	0	0	0	0	0	0	0	0	0	0	0	0	0	23,6	30,2	32,2	33,1	42,9	48,9	242,4	387,6	823,8	1298,5	1419,6
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	265,7
USA	0	0	0	0	0	0	0	0	0	0	0	0	111,0	190,0	295,0	455,0	753,0	1188,0	2040,0	3959,0	7328,0	12079,0	18317,0	25600,0
TOTAL IEA PVPS	46,1	59,8	83,7	103,1	130,9	178,2	236,0	340,2	619,0	887,7	1240,6	1670,5	2797,0	4199,8	5641,7	8145,5	14628,5	21983,7	36690,1	64445,5	88934,2	121738,9	156041,8	196617,7
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	728,9	2833,2	5430,7	9930,2	15409,5	21038,7	31117,8
TOTAL	46,1	59,8	83,7	103,1	130,9	178,2	236,0	340,2	620,1	889,9	1244,0	1687,0	2826,1	4233,4	5679,9	8194,2	14763,1	22712,6	39523,3	69876,2	98864,4	137148,4	177080,5	227735,5

SOURCE SOURCE IEA PVPS & OTHERS.

ANNEX 2: ANNUAL INSTALLED PV CAPACITY (MW) FROM 1992 TO 2015

COUNTRY	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
IEA PVPS COUNTRIES																								
AUSTRALIA	7,4	1,5	1,8	2,0	3,1	3,0	3,7	2,8	3,9	4,4	5,6	6,4	6,6	8,4	9,7	12,1	22,2	83,0	383,3	806,0	1038,2	810,9	861,6	1021,7
AUSTRIA	0	0	0	0	0	0	0	0	0	0	0	0	21,1	3,0	1,6	3,1	3,7	20,2	42,9	91,7	75,7	363,1	159,3	151,8
BELGIUM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23,6	84,9	539,4	417,7	1039,8	694,1	258,8	94,4	97,2
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	2,1	2,9	3,7	5,3	6,9	61,9	186,6	277,2	268,7	444,5	632,6	675,2
CHINA	0	0	0	0	0	0	0	0	3,0	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	15150,0
DENMARK	0	0	0	0	0	0	0	0	0	0	0	0	0	2,7	0,2	0,2	0,1	1,4	2,5	9,6	391,0	155,6	42,3	181,4
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	0	5,0
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	11,6	38,0	104,4	191,3	838,1	1764,1	1120,2	654,1	954,1	887,4
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	1460,6
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	205,0
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	1746,5	403,5	300,0
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	1717,7	6967,5	9739,9	10811,4
KOREA	0	0	0	0	0	0	0	0	0	0	5,4	0,6	2,6	5,0	22,3	45,3	275,7	166,8	126,6	78,8	295,2	530,7	926,3	1011,5
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	29,1	107,0	65,1	26,8
MEXICO	0	0	8,8	0,4	0,8	1,0	1,0	0,9	1,0	0,0	0,0	0,0	2,0	1,0	1,0	1,0	1,0	5,0	4,0	1,0	5,0	31,0	48,2	56,0
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	437,0
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	0,3	0,4	0,4	0,4	0,5	0,6	2,2	2,5
PORTUGAL	0	0	0	0	0	0	0	0	0	0	0	2,0	0	0	2,0	11,0	47,0	48,0	24,0	41,0	69,0	55,0	117,0	49,0
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	54,0
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	47,4
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	11,7	25,7	37,2	100,1	226,3	319,0	305,0	333,0
THAILAND	0	0	0	0	0	0	0	0	0	0	0	0	0	23,6	6,6	2,0	0,9	9,8	6,1	193,5	145,2	436,2	474,7	121,1
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	208,0
USA	0	0	0	0	0	0	0	0	0	0	0	0	111,0	79,0	105,0	160,0	298,0	435,0	852,0	1919,0	3369,0	4751,0	6238,0	7283,0
TOTAL IEA PVPS	40,7	13,7	23,9	19,5	27,7	47,3	57,8	104,2	212,5	268,8	352,9	429,8	1126,6	1402,8	1441,9	2503,8	6483,0	7355,2	14706,4	27755,4	24488,7	32804,6	34302,9	40576,0
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	594,3	2104,3	2597,5	4499,5	5479,3	5629,2	10079,1
TOTAL	40,7	13,7	23,9	19,5	27,7	47,3	57,8	104,2	213,6	269,9	354,1	443,0	1139,1	1407,3	1446,6	2514,2	6569,0	7949,4	16810,7	30352,9	28988,3	38283,9	39932,1	50655,0

SOURCE SOURCE IEA PVPS & OTHERS.

ANNEX 3: REPORTED PRODUCTION OF PV MATERIALS, CELLS AND MODULES IN 2015 IN SELECTED IEA PVPS COUNTRIES

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)	MODULE PRODUCTION (MW): WAFER BASED (SC-SI & MC-SI)	MODULE PRODUCTION (MW): THIN-FILM (A-SI & OTHER)	MODULE PRODUCTION CAPACITY (ALL TYPES, MW/YEAR)
AUSTRALIA									>2,3		60
AUSTRIA									117		261
CANADA[2]		NA							778		1 066
CHINA	165 000		-		48 000		41 010	55 920	45 800		71 000
DENMARK								2	2		3
FINLAND											15
FRANCE		300		100		115		100			600
GERMANY[2]		53 980		NA		1 820		2 323			3 821
ITALY[2]										891	400
JAPAN		13 800					2 787	3 745	2 212		4 640
KOREA[2]		83 000		3 250		2 730		1 630			3 620
MALAYSIA[3]		13 800		NA		1 205		3 260			6 065
NORWAY	6 500		1 000		630					75	
SPAIN[2]		NA							350		425
SWEDEN									1		100
SWITZERLAND								50		2	50
THAILAND							815	924	688	570	4 009
USA	34 853				24		1 198	1 413	751		17 10

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 FIGURES FROM NSR 2014.
3 POLYSILICON CAPACITY SOURCE: RTS CORPORATION.

SOURCE IEA PVPS, RTS CORPORATION.

ANNEX 4: AVERAGE 2015 EXCHANGE RATES

COUNTRY	CURRENCY CODE	EXCHANGE RATE (1 USD =)
AUSTRALIA	AUD	1,33
AUSTRIA, BELGIUM, FINLAND, FRANCE, GERMANY, ITALY, THE NETHERLANDS, PORTUGAL, SPAIN	EUR	0,90
CANADA	CAD	1,28
CHINA	CNY	6,28
DENMARK	DKK	6,73
ISRAEL	ILS	3,89
JAPAN	JPY	121,06
KOREA	KRW	1 132,33
MALAYSIA	MYR	3,91
MEXICO	MXN	15,79
NORWAY	NOK	8,07
SWEDEN	SEK	8,44
SWITZERLAND	CHF	0,96
THAILAND	THB	34,25
TURKEY	TRY	2,73
UNITED STATES	USD	1,00

SOURCE XE.

LIST OF FIGURES & TABLES

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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