Technology Collaboration Programme
by iea

International Energy Agency
Photovoltaic Power Systems Programme

Task 1 Strategic PV Analysis and Outreach

PVPS

Snapshot of Global PV Markets 2021

Report IEA-PVPS T1-39: 2021

What is IEA PVPS TCP?

The International Energy Agency (IEA), founded in 1974, is an autonomous body within the framework of the Organization for Economic Cooperation and Development (OECD). The Technology Collaboration Programme (TCP) was created with a belief that the future of energy security and sustainability starts with global collaboration. The programme is made up of 6000 experts across government, academia, and industry dedicated to advancing common research and the application of specific energy technologies.

The IEA Photovoltaic Power Systems Programme (IEA PVPS) is one of the TCPs 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.

The IEA PVPS participating countries are Australia, Austria, Belgium, Canada, Chile, China, Denmark, Finland, France, Germany, Israel, Italy, Japan, Korea, Malaysia, Mexico, Morocco, the Netherlands, Norway, Portugal, South Africa, Spain, Sweden, Switzerland, Thailand, Turkey, and the United States of America. The European Commission, Solar Power Europe, the Smart Electric Power Alliance (SEPA), the Solar Energy Industries Association and the Copper Alliance are sponsor members.

Visit us at: www.iea-pvps.org

What is IEA PVPS Task 1?

The objective of Task 1 of the IEA Photovoltaic Power Systems Programme is promoting and facilitating the exchange and dissemination of information on the technical, economic, environmental and social aspects of PV power systems. Task 1 activities support the broader PVPS objectives: to contribute to cost reduction of PV power applications, to increase awareness of the potential and value of PV power systems, to foster the removal of both technical and non-technical barriers and to enhance technology co-operation.

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INTERNATIONAL ENERGY AGENCY

PHOTOVOLTAIC POWER SYSTEMS PROGRAMME

IEA PVPS
Task 1
Strategic PV Analysis and Outreach

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EXECUTIVE SUMMARY

Despite the COVID-19 pandemic, preliminary reported market data shows that the global PV market again grew significantly in 2020. At least 139,4 GWdc of PV systems have been installed and commissioned in the world last year. The total cumulative installed capacity for PV at the end of 2020 reached at least 760,4 GWdc. While these data will have to be confirmed in the coming months, some important trends can already be extracted:

- The Chinese PV market went back to a market level it experienced in 2017, after two years in a row of market slowdown. In 2020, 48,2 GW of PV were installed, compared to 43,4 GW in 2018 and 30,1 GW in 2019. China remains the leader in terms of cumulative capacity with 253,4 GW installed, almost one third of the global PV installed capacity.
- Outside of China, the global PV market grew from 79,2 GW in 2019, to at least 90 GW in 2020, a 14% increase year on year.
  - The European Union installed close to 19,6 GW and the rest of Europe added around 2,6 GW. The largest European market in 2020 was Germany (4,9 GW), followed by the Netherlands (3,0 GW), Spain (2,8 GW), Poland (2,6 GW), Belgium (1,0 GW) and France (0,9 GW).
  - The US market saw its market increasing to 19,2 GW; a new record, with utility-scale installations accounting for about 73% of the new additions.
  - Vietnam takes the fourth place with an impressive annual installation of 11 GW.
  - Japan ranks fifth, with an estimated 8,2 GW annual installed capacity.
  - Some other key markets contributed significantly to new additions in 2020, such as India (close to 5 GW, but in significant decline compared to last years), Australia (4,1 GW), Korea (4,1 GW), Brazil (3,1 GW), Taiwan (1,7 GW), Mexico (1,5 GW), followed by the Philippines (1,1 GW) and South-Africa (1,0 GW). Preliminary numbers show to Mexico and South Africa could have installed close to 1 GW as well.
  - Among the top 10 countries, there are now six Asia-Pacific countries (Australia, China, India, Japan, Korea and Vietnam), two European countries (Germany and the Netherlands) and two countries in the Americas (Brazil and the USA).
- The level to enter the top 10 global markets in 2020 was around 3,0 GW; a stable level compared to 2019 and twice the level needed in 2018.
- The top 10 countries represented around 78% of the global annual PV market, a slight increase compared to 2019. However, compared to previous years, the market is still showing a decreasing market concentration trend.
- Honduras, Australia, Germany, Greece, Chile, Spain, the Netherlands, Italy, Japan, Israel, Belgium, India, China, and Turkey now have enough PV capacity to theoretically produce more than 5% of their annual electricity demand with PV. PV represents around 3,7% of the global electricity demand.

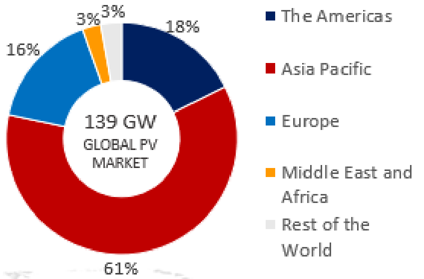
The contribution of PV to decarbonizing the energy mix is progressing, with PV saving as much as **875 million tons of CO_2eq**. However, much remains to be done to fully decarbonize and PV deployment should increase by at least one order of magnitude to cope with the targets defined during the COP21 in Paris, France.

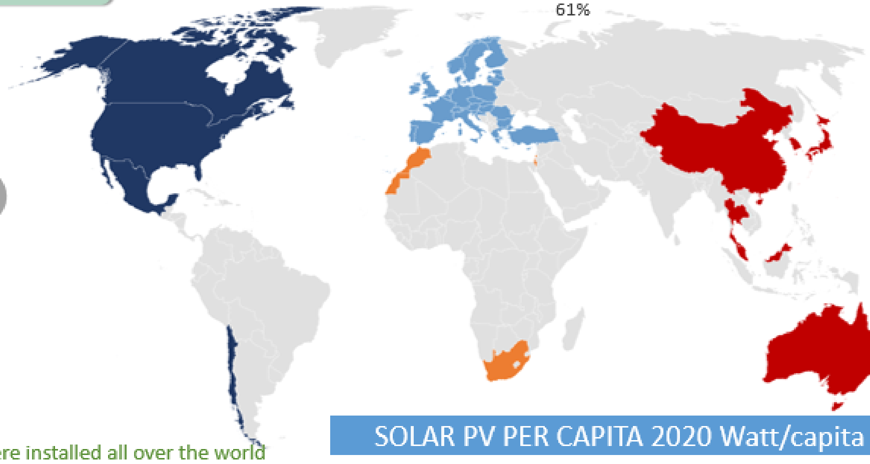
International Energy Agency
Photovoltaic Power Systems Programme

A Snapshot of Global PV Markets

TOP PV MARKETS 2020

CHINA	48,2 GW
EU	19,6 GW
USA	19,2 GW





CO_2eq

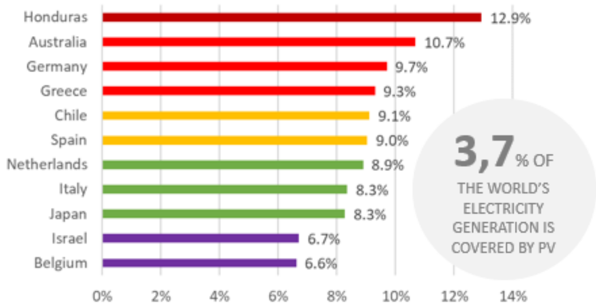
877 Mt
CO_2 emissions
avoided in 2020

- 760,4 GW were installed all over the world by the end of 2020
- China is the world's #1 PV market
- 20 countries installed at least 1 GW of PV in 2020
- 14 countries have installed at least 10 GW of cumulative capacity at the end of 2020

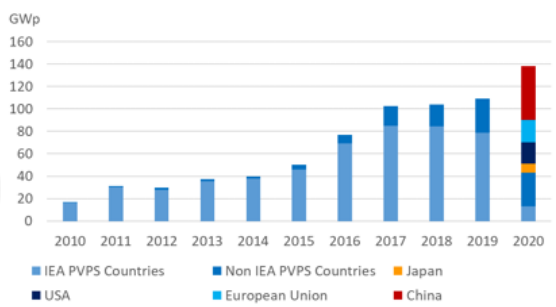
SOLAR PV PER CAPITA 2020 Watt/capita

		Watt/capita
1st	AUSTRALIA	795
2nd	GERMANY	649
3rd	JAPAN	565

COUNTRIES WITH HIGHEST PV PENETRATION



EVOLUTION OF ANNUAL PV INSTALLATIONS



1 SNAPSHOT OF THE GLOBAL PV MARKET IN 2020

IEA PVPS has distinguished itself throughout the years by producing unbiased reports on the development of PV all over the world, based on information from official government bodies and reliable industry sources. This 10th edition of the "Snapshot of Global PV Markets" aims at providing **preliminary information** on how the PV market developed in 2020. The 27th edition of the PVPS complete "*Trends in Photovoltaic Applications*" report will be published in Q4 2021.

At least 139,4 GWdc of PV systems have been commissioned in the world last year of which the IEA PVPS countries represented 109,7 GW.

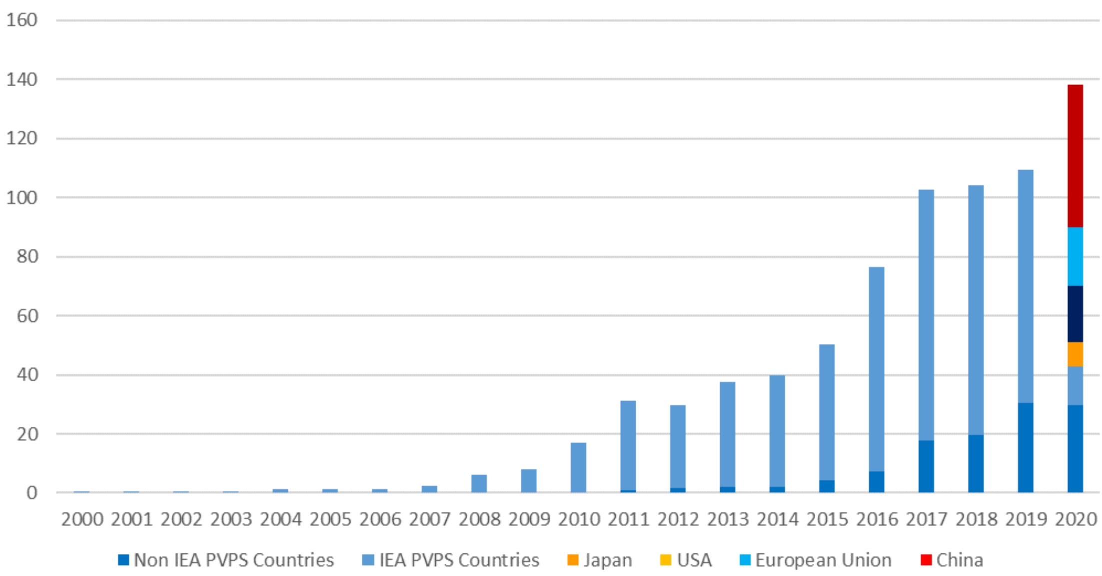
The IEA PVPS countries represented 644,0 GW of cumulative PV at the end of 2020. The IEA PVPS continues to cover 27 countries with at least 85% of the global PV capacity.

Next to the members of the IEA PVPS programme, the other major markets in the world represent at least 97,6 GW cumulative installed capacity at the end of 2020.

At present, it appears that 744,6 GW represents the minimum installed by end 2020, with a firm level of certainty in the IEA PVPS countries and the other major markets. Remaining markets account for an estimated additional 15,8 GW that could bring the total cumulative installed capacity to around 760,4 GWdc.

In 2020, at least 20 countries installed more than 1 GW. Fourteen countries now have more than 10 GW of total cumulative capacity, five have more than 40 GW. China alone represented 253,4 GW followed by the European Union (as EU27), which used to lead the rankings for years and ranks second since 2015 (151,3 GW), the USA ranks third (93,2 GW) and Japan fourth (71,4 GW).

FIGURE 1: EVOLUTION OF ANNUAL PV INSTALLATIONS

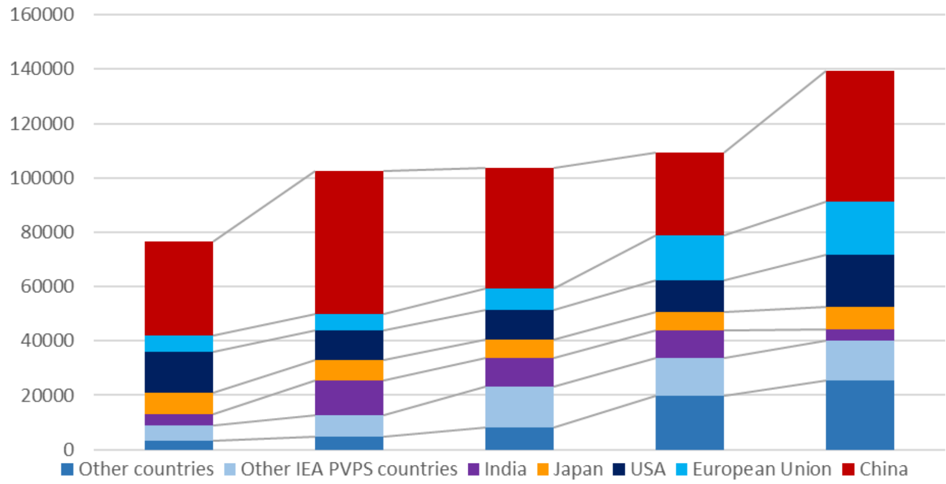


Source: IEA PVPS

Evolution of regional PV markets

The majority of the growth of the PV market in 2020 came from China, Vietnam and to a lesser extent from the EU and the USA. Other markets saw some additions, while India experienced the most important market decrease of the year. Figure 2 below illustrates the changing dynamics of the global PV market, and the huge influence of the Chinese PV market. However, the positive dynamics of the other countries show a constant progress in the last years, despite some localized negative effects.

FIGURE 2: 2016-2020 GROWTH PER REGION



Source: IEA PVPS

Impact of the COVID-19 pandemic

Overall, the COVID-19 pandemic did not significantly impact market development in 2020. While some delays were incurred by the lockdown measures during Q1, the time lost was largely restored during Q3 and Q4 in most of the countries. The national market regressions or stagnations discussed above can be linked to regulatory burdens.

The resiliency of the PV market despite the major economic and logistic disruptions is remarkable and shows the potential of the technology to limit the economic downturn and social damage brought by the COVID-19 pandemic. This shows that national green recovery plans and better regulations could propel the PV industry far beyond the current installation trends (which is needed to achieve the Paris Climate Agreement).

2 THE TOP 10 MARKETS IN 2020

After two years of contraction, the Chinese market renewed growth with 48,2 GW installed in 2020. This represented 35% of the global market. Behind China, the European Union ranked second with around 19,6 GW of annual installations in 2020. The USA followed with an increased market of 19,2 GW, followed by Vietnam where a staggering 11 GW were installed. Japan closes the top five with an estimated 8,2 GW, an increased market level compared to 2018 and 2019.

Behind these countries, changes were less visible, except in India that experienced a major market contraction down to around 5 GW. This was mostly due to uncertainties and regulations while the official targets remain high. Korea (growing) and Australia (stable) both installed about 4,1 GW; Brazil installed 3,1 GW, becoming the most dynamic market in Latin America. Looking a bit more in depth at European Union countries, Germany experienced another growth year, with about 4,9 GW of additional capacities installed and the Netherlands continued to massively install PV with 3,0 GW after 3,4 GW in the previous year.

As in 2019, 10 out of the top 10 markets for PV in 2020 have installed at least 3 GW of PV systems, compared to 1,5 GW in 2018.

Several countries which in previous years installed significant capacities have left the top 10 for annual installed capacities, such as France, Mexico and Turkey. These countries still experienced significant market developments, however, not enough to stay in the top 10.

The top 10 of total cumulative installed capacities shows more inertia due to past levels of installations: Italy and the UK have left the top countries in terms of annual installations several years back, but their past developments still allow them to stay in the top 10 for cumulative installed capacity.

As mentioned in the next section, capacities for a few countries that report PV installations in **AC** power, have been converted into **DC** power to facilitate comparison. This can lead to discrepancies with official PV data in several countries such as Spain, Japan or India.

TABLE 1: TOP 10 COUNTRIES FOR INSTALLATIONS AND TOTAL INSTALLED CAPACITY IN 2020

FOR ANNUAL INSTALLED CAPACITY			FOR CUMULATIVE CAPACITY		
1	China	48,2 GW	1	China	253,4 GW
(2)	*European Union*	19,6 GW	(2)	*European Union*	*151,3 GW*
2	United States	19,2 GW	2	United States	93,2 GW
3	Vietnam	11,1 GW	3	Japan	71,4 GW
4	Japan	8,2 GW	4	Germany	53,9 GW
5	Germany	4,9 GW	5	India	47,4 GW
6	India	4,4 GW	6	Italy	21,7 GW
7	Australia	4,1 GW	7	Australia	20,2 GW
8	Korea	4,1 GW	8	Vietnam	16,4 GW
9	Brazil	3,1 GW	9	Korea	15,9 GW
10	Netherlands	3 GW	10	UK	13,5 GW

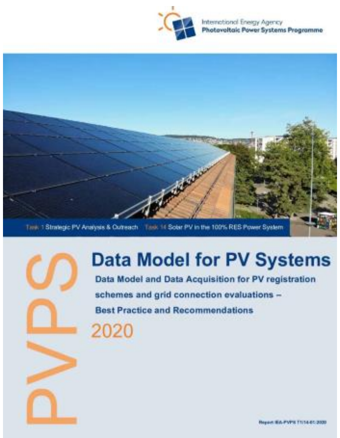
Source: IEA PVPS

* The European Union grouped 27 European countries in 2020, out of which Germany, the Netherlands and Italy also appear in the Top 10, either for the installed capacity or the annual installations.

3 AC OR DC NUMBERS

IEA PVPS counts all PV installations, both grid-connected and off-grid, when numbers are reported. By convention, the numbers reported refer to the nominal power of PV systems installed. These are expressed in W (or W_p). Some countries are reporting the power output of the PV inverter (the device converting DC power from the PV system into AC electricity compatible with standard electricity networks) or the grid connection power level. The difference between the standard DC power (in W_p) and the AC power can range from as little as 5% (conversion losses, inverter set at the DC level) to as much as 60%. For instance, some grid regulations limit output to as little as 70% of the peak power from the residential PV system installed in the last years. Most utility-scale plants built in 2020 have an AC-DC ratio between 1,1 and 1,6. For some countries, numbers indicated in this report have been transformed to DC numbers to maintain the coherency of the overall report.

In general, IEA PVPS recommends registering PV systems with both the DC power and the AC value. DC power gives a precise idea of the installed capacity, regardless of the grid connection (if any) and allows a reliable calculation of the energy production. On the other hand, AC power allows grid operators to better understand the maximum power output of the PV fleet. However, the AC value must be defined precisely since the AC output of many inverters can exceed the nominal value during small periods of time. On the other side, AC limits on the grid connection side do not always reflect the nominal capacity of PV plants. More information about recommendations to properly register PV plants can be found in the following report:



IEA PVPS Report:

Data Model and Data Acquisition for PV Registration Schemes and Grid Connection – Best Practice and Recommendations

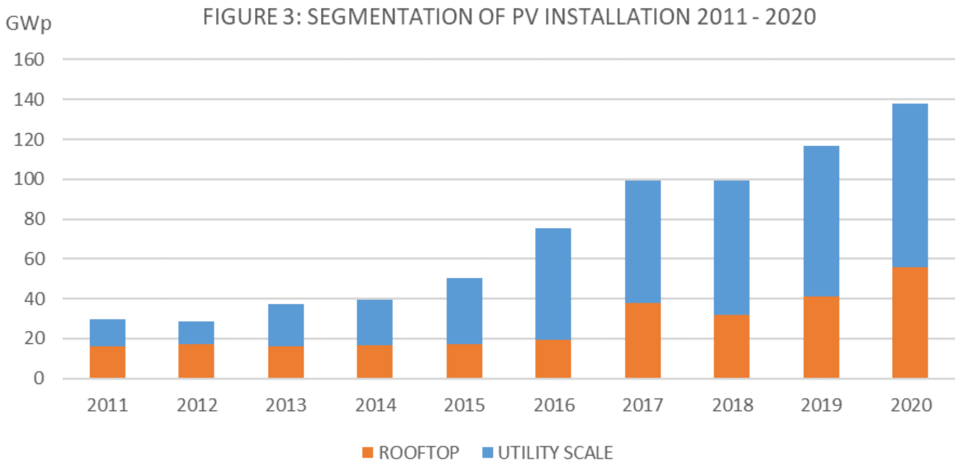
Download the report:

https://iea-pvps.org/

or scan the QR code.

4. MARKET SEGMENTATION

Preliminary data show that the utility-scale PV market slightly increased in absolute numbers compared to 2019. However, it relatively decreased in market share as the rooftop market increased more significantly. The rooftop market grew in 2020, mainly due to a strong push from Vietnam but also some growth in Australia, Germany and the United States.



Source: IEA PVPS

The market has also started to diversify in terms of other type of applications, with floating PV adding to utility-scale and BIPV starting to complement BAPV in the built environment. Other emerging segments such as agricultural PV are hardly visible yet. From a technology point of view, some evolutions have been notable, such as the start of bifacial PV development. PV integrated in vehicles is showing the potential for further diversification of PV components, but its current market level remains too low to be considered in this publication.

4 CUMULATIVE INSTALLED CAPACITY IN THE WORLD

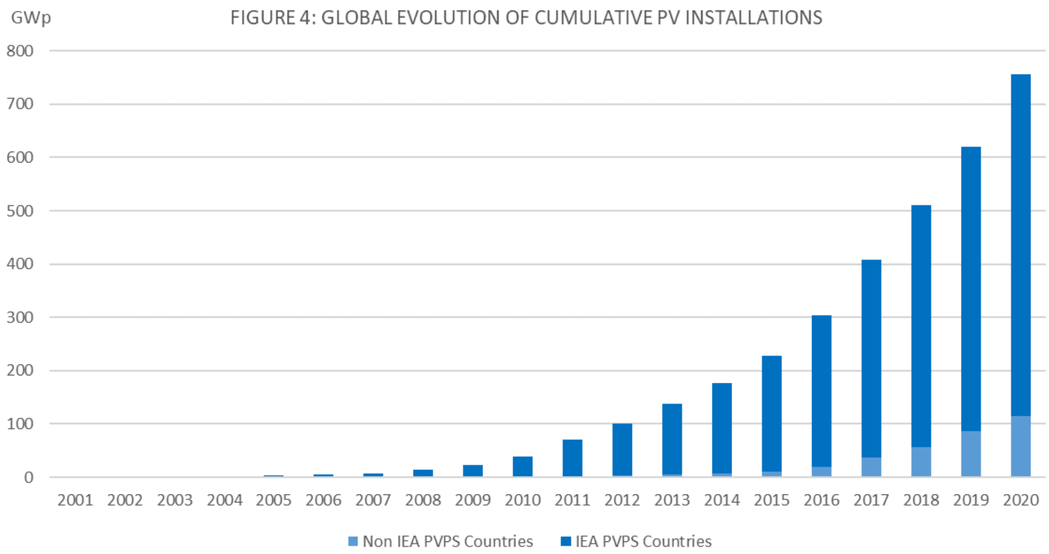
As illustrated in Figure 4, the total cumulative installed capacity at the end of 2020 globally amounted to at least 758,9 GW.

China continues to lead with a cumulative capacity of 253,4 GW, followed by the European Union (151,2 GW), the USA (93,2 GW), Japan (71,4 GW) and India (47,4 GW). In 2020, Australia reached 20,2 GW cumulative installations, Vietnam 16,4 GW and Korea 15,9 GW.

In the European Union, Germany leads with 53,9 GW, followed by Italy (21,7 GW), Spain (12,7 GW), France (10,9 GW) and the Netherlands (10,2 GW).

All other countries are below the 10 GW mark.

FIGURE 4: GLOBAL EVOLUTION OF CUMULATIVE PV INSTALLATIONS



Source: IEA PVPS

Decommissioning, Repowering and Recycling

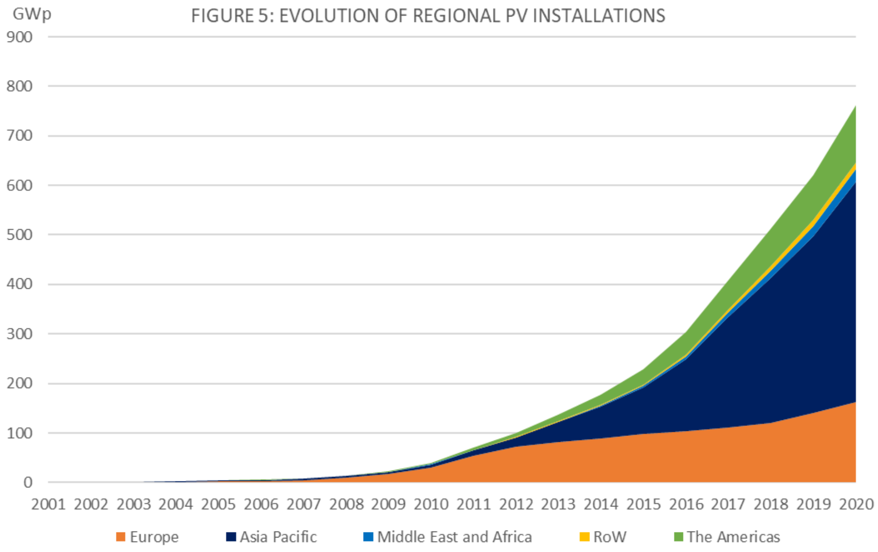
So far, numbers published by IEA PVPS consider the annual installations and total cumulative installed capacities based on official data in reporting countries. Several countries already incorporate decommissioning of PV plants in their total cumulative capacity numbers by reducing the total cumulative number. However, it is believed that many countries do not track decommissioning properly, and even more problematic, repowering.

It is assumed that real decommissioning is relatively unusual given the age of the oldest installations after the real market started around 2005. Replacement of components, and in particular, PV modules and inverters are part of the usual maintenance and operation business, but in general it does not impact the total cumulative capacity. Recycling numbers can provide a glimpse of what is happening in this field. However, recycling schemes are not yet common, and the availability of data must be improved.

In the coming years, IEA PVPS will follow the dynamic evolution of decommissioning, repowering and recycling closely, with the expected impact on the installed capacity, market projections for repowering and the decline in PV performances due to ageing PV systems.

5 EVOLUTION OF REGIONAL PV INSTALLATIONS

While Europe played a key pioneering role in the early developments of PV, Asia's share started to grow rapidly in 2012 and it has not stopped since then (see Figure 5). Driven by China, India, Japan, Korea and more recently Vietnam, Asia represented around 57% of the total cumulative installed capacity in 2020 - a significant increase due to the Chinese market rebound and the spectacular growth of Vietnam. With the fast growth of the Asian market, Europe is losing its share year by year, despite the renewed and significant growth for the third year in a row. At the end of 2020, Europe represented 22% of the total cumulative installed PV capacity, out of which the European Union accounted for 93%. The Americas represented 15%, thanks to the USA and some Latin American countries such as Brazil, while the remaining 6% came from the MEA region and the rest of the world (unidentified installations).



Source: IEA PVPS

Asia continues to dominate the global PV market with China as a global leader. Some already established major Asian markets, such as China, Japan, Korea, Taiwan or Malaysia, experienced a growth in 2020, while India contracted. The development in other markets, such as Thailand, Singapore, Indonesia and the Philippines has been slow or intermittent over the years. Vietnam now ranks amongst the top markets for the second year in a row, but it is unsure whether such an installation level will be sustained. Asian markets represented around 61% of the global PV market in 2020, a slight increase compared to the level in 2019, but in line with previous years.

In the Americas, the market increased slightly, mainly through the US market which experienced accelerated growth (19,2 GW) in 2020. Brazil is the second market with around 3,1 GW installed in 2020, followed by Mexico which installed around 1,5 GW, Chile with 790 MW and Argentina installed around 320 MW, a decrease after its record level of 2019. The market in Canada was quite limited again with around 200 MW installed capacity in 2020. The Americas represented around 18% of the global PV market in 2020.

In the European Union, Germany took the lead with 4,9 GW, a significant increase for the third year in a row. The Netherlands with 3,0 GW experienced significant market additions for the third time in a row, followed by Spain that installed 2,8 GW and Poland with 2,6 GW, Belgium crossed the GW mark with 1,0 GW. France installed 0,9 GW, Italy progressed again with around 0,8 GW. The ranking continued with Sweden (506 MW), Austria (350 MW), Denmark (135 MW), Portugal (124 MW), Finland (60 MW) and Norway (40 MW).

Other countries in Europe, experienced interesting developments: one can cite Hungary (around 600 MW), the UK (545 MW) and Switzerland (430 MW). Europe as a whole represented slightly more than 16% of the global PV market in 2020.

In the Middle East and Africa, Israel installed an additional 0,6 GW, about the same as in the previous year, but less than expected, due to COVID-19 delays. In the United Arab Emirates very few projects came online despite the tenders in the previous years. In Oman, several projects that were in the pipeline came online in 2020, for a total of 355 MW. Turkey installed almost 1 GW - a stable market level compared to 2019. In Africa, South Africa installed an estimated 1,0 GW (mostly distributed applications) and several installations were recorded in Ethiopia (250 MW) and Mali (75 MW).

Africa and the Middle East represented around 3% of global PV installations in 2020.

6 ELECTRICITY PRODUCTION FROM PV

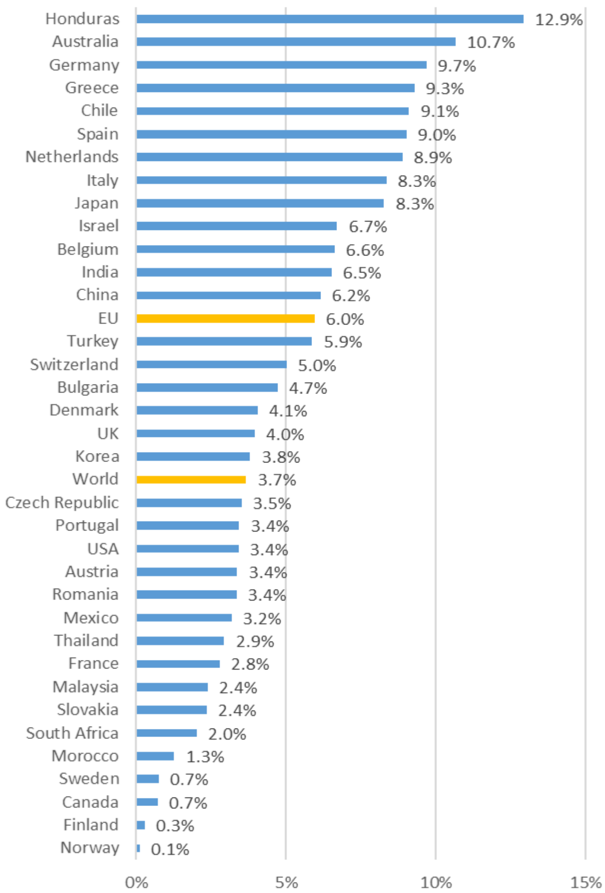
PV electricity production is easy to measure for an individual power plant but much more complicated to compile for an entire country. First, solar irradiation can vary depending on the local climate and the weather can show some significant differences from one year to another. Furthermore, a system installed in December, will have produced only a small fraction of its regular annual electricity output; systems installed on buildings may not be at optimum orientation or may have partial shading during the day. For these reasons, the electricity production from PV per country, as shown below, estimates what the PV production could be based on the cumulative PV capacity at the end of 2020, close to optimum siting, orientation and long-term average weather conditions.

Figure 6 shows how PV theoretically contributes to the electricity demand in key countries (IEA PVPS and others), based on the PV capacity installed by the end of 2020. Since these numbers are estimates based on the total cumulative capacity at the end of the year, they can slightly differ from official PV production numbers in some countries. These numbers should be considered as indicative, they provide a reliable estimation of the production in different countries and allow comparison between countries but do not replace official data.

In several countries, the PV contribution to the electricity demand has passed the 5% mark with Honduras in first place with almost 13%. Australia is second with an estimated 10,7% and Germany third with a theoretical penetration level of 9,7%.

In total, PV contribution amounts to close to 3,7% of the electricity demand in the world.

FIGURE 6: THEORETICAL PV PENETRATION 2020



Source: IEA PVPS

7 POLICY & MARKETS TRENDS

7.1 Competitive Tenders & Merchant PV

Tenders continued to be granted in several places in the world with extremely competitive prices, around 20 USD/MWh in the sunniest places. Winning bids even below 20 USD/MWh have been reported in the Middle East and Portugal (even if this one can be discussed) where prices below 14 USD/MWh have been recorded. The decreasing price trend continues, and most believe prices will continue to go down in the coming years, however probably at a reduced pace.

In some countries, cost-based tenders evolve towards multiple-factors tenders. Environmental or industrial constraints are introduced to give an advantage to local companies or to favour a better environmental footprint of the products.

Merchant PV, with PV electricity sold on electricity markets or through PPAs has been seen in an increasing number of countries in 2020, with perspectives for further development in the coming years. Therefore, in addition to tenders, utility-scale PV starts to develop outside of the framed tenders and similar policies, thereby bringing cheap electricity to the world.

7.2 Prosumers Policies

The idea that PV producers could be considered as “prosumers” – both producers and consumers of energy – is evolving rapidly and policies are being adapted accordingly in several countries.

The first set of policies used to develop the market of small-scale PV installations on buildings were called “net-metering” policies and were adopted in a large number of countries, however, with different definitions. The genuine “net-metering” which offers credits for PV electricity injected into the grid, have previously supported market development in Belgium, Canada, Denmark, the Netherlands, Portugal, Korea and the USA, but such policies are increasingly replaced by self-consumption policies favouring real-time consumption of PV electricity, often completed with a feed-in tariff (or feed-in premium in addition to the spot price) for the excess PV electricity fed into the grid. As a result, self-consumption is becoming a major driver of distributed PV installations.

The use of self-consumption in collective buildings is not yet widespread but exists in the Netherlands, Austria, Sweden, France, Switzerland and in Germany. In Italy, new rules about self-consumption for consumers acting collectively were approved. The idea of virtual self-consumption between distant points has been tested in Mexico, Brazil, France and Australia, and it is now possible under certain circumstances in the Netherlands. In many countries, such policies encounter a fierce resistance from many distribution system operators who fear for their future financing. With a growing share of distributed generation and self-consumption, the question of grid finance is a key issue to address.

In the Clean energy for all Europeans package, the European Union introduced the concept of Renewable Energy Communities (REC) and of Citizen Energy Communities (CEC). REC should allow citizens to sell renewable energy production to their neighbours, while some crucial components are the definition of the perimeter and the tariffication for grid use. Those key components are defined in the national implementation in the member states. Collective self-consumption beyond individual buildings has been introduced in Switzerland in the new Energy Act in 2018 (as long as the public grid is not used) and is likely to expand existing PV market segments and to allow cost reductions for consumers not able to invest in a solar installation themselves.

Decentralized or distributed self-consumption is starting to develop with the idea to disconnect production and consumption of PV electricity. This would allow one or several PV producers (even utility-scale plants) to feed one or more consumers at a reasonable distance so that the use of the public grid is minimized. Such disconnection between production and consumption would help to alleviate the constraint of the local self-consumption ratio and allow for a better use of available space on roofs or land. France, the Netherlands and Australia allow it under different forms, mostly for small-scale installations.

7.3 Measures Penalizing Existing Installations and Retroactive Measures

Some of the support schemes implemented in the early stages of PV development, have been the victim of their own success in the year 2010. Especially the schemes not designed to consider rapid cost declines, or those without any budget or capacity cap attracted investments that largely exceeded expectations. In Europe, one can cite Belgium, Bulgaria, Czech Republic, France, Greece, Italy, Romania and Spain.

These fast and important market developments significantly increased the burden on government budgets or on end-consumers electricity bills. Therefore, some governments retroactively decided to reduce the payments towards producers. These sometimes illegitimate measures have been fought back by the investors, sometimes resorting to international tribunals. The country where the most legal actions have been undertaken are the Czech Republic Spain where the FiT have been reduced to cap the profit of the PV projects. In Italy, among other cases, tariffs reduction was coupled with an extension of the incentive period (a measure introduced in 2014).

Meanwhile, most of these markets re-experienced significant PV market growth, however it took years to regain investors' confidence. On top of the faulty design, the risk of government retroactively scaling back incentives is higher in countries that experience financial hardship. Therefore, investors should remain cautious when PV market conditions seem too attractive in weak economies (for instance high level of unemployment and inflation or high annual debt-to-GDP ratio).

More recently, Ukraine defined several levels of retroactive cuts on the FiT allocated to different PV capacity segments installed after 2015. After several rounds of discussions with the sector, the cuts were not as hard as initially feared.

Discussions are ongoing in France, as the government considers a FiT reduction for PV plants installed before 2011. The renegotiation would allow some cost savings for the government, which might be tempting in the difficult economic context shaped by the COVID-19 pandemic.

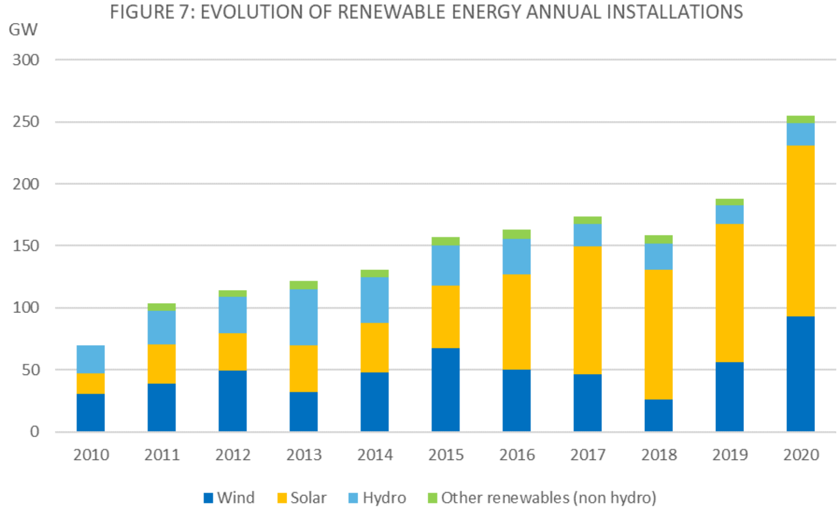
Retroactive measures undermine investors' confidence and market stability. However, given the increased competitiveness of PV solutions, such measures are vanishing rapidly from the agenda of policymakers in most countries.

8 PV IN THE BROADER ENERGY TRANSITION

8.1 PV and Other Renewable Energy Evolutions

PV will play a key role in the energy transition. This trend is already visible when looking at the evolution of the renewable energy technologies as shown in Figure 7. In the last 15 years, PV technology has shown an ever-increasing market growth thanks to technology and price development. In the last three decades, PV has gone from being a niche technology mostly used for electricity production either in space or in remote places to a mainstream energy source.

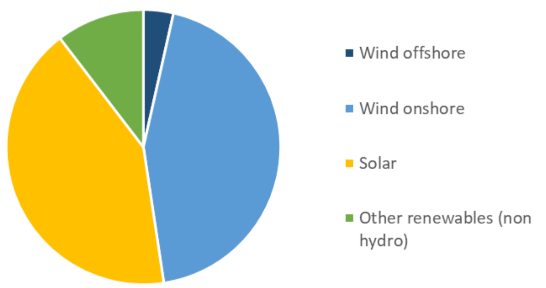
FIGURE 7: EVOLUTION OF RENEWABLE ENERGY ANNUAL INSTALLATIONS



Sources: compilation of IEA PVPS, GWEC, IRENA and estimations for 2020

In 2020, solar PV stood for approximately 42% of the total renewable electricity production from new production assets. The difference with the figure above is due to the different capacity factors of renewable technologies. Whereas biomass installations can virtually produce all day and all year-round, wind and solar installations' output strongly depend on the available resources that can vary locally.

FIGURE 8: ELECTRICITY PRODUCTION OF THE RENEWABLE ENERGY CAPACITY INSTALLED IN 2020



Sources: IEA PVPS, GWEC and estimations for 2020

8.2 Impact of PV Development on CO_2 Emissions

Global energy related CO_2eq emissions have been around 30 Gt in 2020, an historic decrease that can mainly be incurred to the COVID-19 pandemic which severely impacted the global energy demand, both in transport as in the industry. The second reason for this decrease can be attributed to the progress of renewable sources (mainly wind and PV), in addition to fuel switching from coal to natural gas and higher nuclear power output. The total emissions of the power sector have reached close to 12,5 Gt of CO_2eq in 2020, a 3,3% lower level than 2019.

The role played by PV in the reduction of the CO_2 emissions from electricity is continuously increasing. Based on the total electricity generated by the cumulative PV capacity installed globally at the end of 2020, around **875 Mt** of annual CO_2 emissions were avoided. This amount is calculated based on the emissions that would have been generated from the same amount of electricity produced by the different grid mixes in all countries and taking into consideration life cycle emissions of PV systems. This represents around 6,7% of the total power sector emissions.

8.3 PV Fostering Development of a Cleaner Energy System

In addition to directly fighting rising CO_2 emissions by offering an alternative to fossil-based electricity production, the deployment of PV technology can also work as a catalyst for other technologies with a potential to tackle climate change. Indeed, PV is now the most competitive electricity source in some market segments. The availability of this cheap electricity is starting to allow the breakthrough of green fuels.

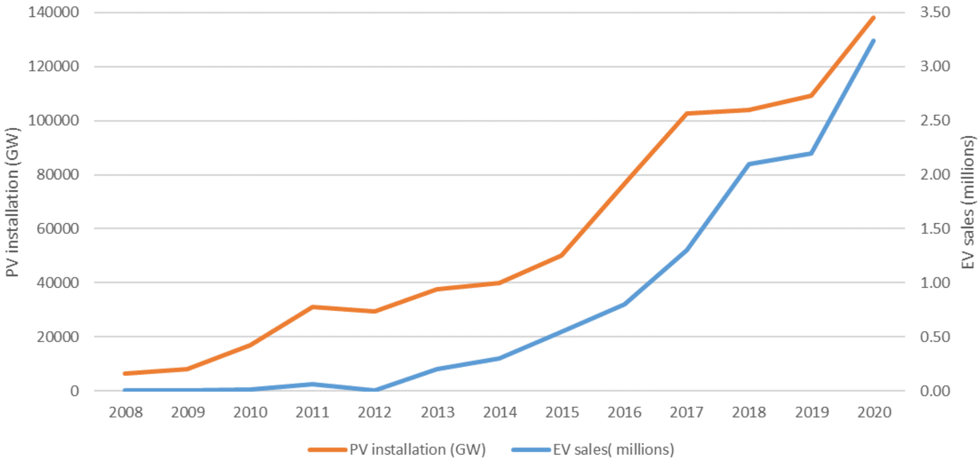
Given the need for seasonal storage, one key technology for the energy transition, is probably green hydrogen production. After years of research and pilot projects, the first commercial green hydrogen plants are being built all over the world:

- In Belgium, the Colruyt Group opened its first public hydrogen filling station. Customers can buy conventional and green fuels as well as 100% green hydrogen.
- Hygreen Provence is a PV and power to gas project located in south-eastern France. It aims to produce 1 300 GWh of photovoltaic electricity by 2027. 600 GWh of electricity will power electrolysers to produce hydrogen. Hydrogen will be used as fuel for transport or it will be stored in underground chambers.
- In Japan, the construction of a large-scale hydrogen energy system has started in the Fukushima prefecture. The 10 MW class hydrogen production facility will start operation in 2020. The hydrogen will be used to power fuel cell vehicles and to support factory operations.
- In Switzerland, the construction of a 2 MW commercial electrolyser has been announced by Alpiq and H2Energy to use hydropower to produce hydrogen for fuel cell-powered electric lorries.
- In Germany, a national hydrogen roadmap was published by the Federal Ministry of Economic Affairs and Energy in June 2020.
- In Spain, a solar PV plant in combination with hydrogen has been announced in Mallorca and should start operation in 2021.

Another example of synergies between PV and other sectors are electric vehicles (EV).

The electrification of transport is accelerating in many countries; and almost all of which are active in the IEA PVPS Technology Collaboration Programme. The link between PV development and EVs is not straightforwardly understood yet, but it is simply becoming a reality with the growth of self-consumption policies. Charging electric vehicles during peak load hours implies to rethink power generation, while concepts such as virtual self-consumption could rapidly provide a framework for rapid PV development. The accelerated development of the EV market could be compared to the development of the PV market. With more than 3 million electric vehicles sold in 2020 alone, with an increase of at least 40% compared to 2019, the penetration of EVs is likely to breakthrough more quickly than PV did initially.

FIGURE 9: EVOLUTION OF EV AND PV ANNUAL GROWTH



Source : IEA PVPS & EV Volumes

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