Technology Collaboration Programme
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International Energy Agency
Photovoltaic Power Systems Programme

Task 1 Strategic PV Analysis and Outreach

PVPS

Snapshot of Global PV Markets 2020

Report IEA-PVPS T1-37: 2020

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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April 2020

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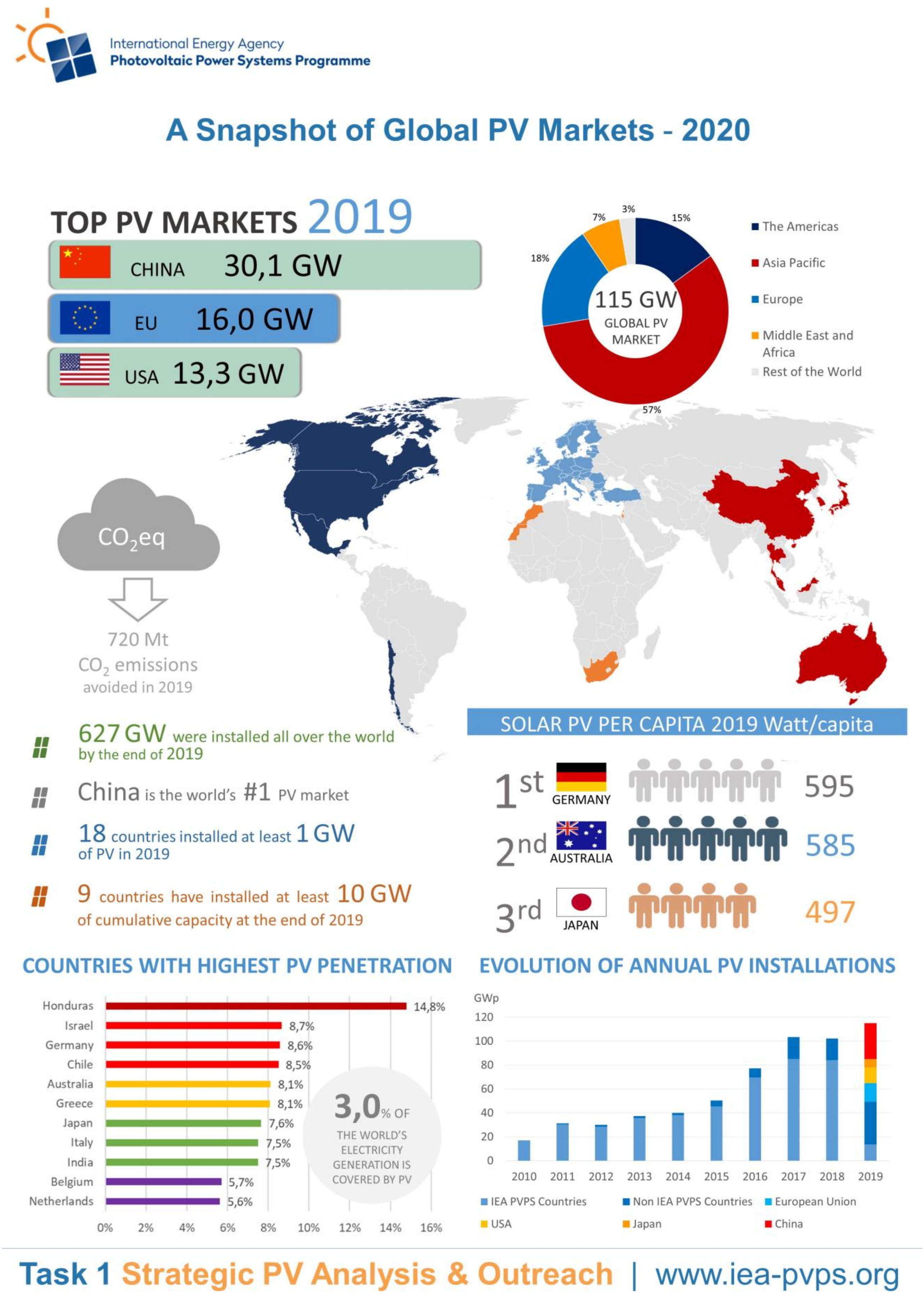
EXECUTIVE SUMMARY

After a year of market stabilization, preliminary reported market data shows a global annual PV market at a slightly higher level than 2018 and 2017. At least 114,9 GW of PV systems have been installed and commissioned in the world last year. The total cumulative installed capacity for PV at the end of 2019 reached at least 627 GW. While these data will have to be confirmed in the coming months, some important trends can already be discerned:

- The Chinese PV market contracted for the second year in a row; from 53,0 GW in 2017 to 43,4 GW in 2018 and 30,1 GW in 2019. However, China remained the leader in terms of total capacity with 204,7 GW cumulative capacity installed, almost one third of the global PV installed capacity.
- Outside of China, the global PV market grew from 58,8 GW in 2018 to at least 84,9 GW in 2019, a 44% increase YoY.
    - The European Union installed close to 16 GW and the rest of Europe added roughly 5 GW. The largest European market in 2019 was Spain (4,4 GW), followed by Germany (3,9 GW), Ukraine (3,5 GW), the Netherlands (2,4 GW), and France (0,9 GW).
    - The US market increased to 13,3 GW, with utility-scale installations accounting for roughly 60% of new additions.
    - India decreased slightly, with the annual market reaching 9,9 GW, including around 1,1 GW of distributed and off-grid installations during 2019
    - Japan ranks fifth, with an estimated 7 GW annual installed capacity.
    - Some other major markets contributed significantly in 2019, such as Vietnam (4,8 GW), Australia, with close to 3,7 GW, Korea with 3,1 GW, Brazil (2,0 GW), the United Arab Emirates (2,0 GW), Egypt (1,7 GW), Taiwan (1,4 GW), Israel (1,1 GW), Mexico (1,0 GW), followed by a declining market in Turkey (0,9 GW).
- In the top 10 countries, there are now six Asia-Pacific countries (China, India, Japan, Vietnam, Australia and Korea), three European countries (Spain, Germany and Ukraine) and one country in the Americas (the USA).
- The level to enter the top 10 markets in the world in 2019 was around 3,1 GW, the highest level ever and twice the level needed in 2018.
- The top 10 countries represented 72% of the global annual PV market, a declining number signally that the market is less concentrated.
- Honduras, Israel, Germany, Chile, Australia, Greece, Japan, Italy, India, Belgium, the Netherlands and Turkey now have enough PV capacity to theoretically produce more than 5% of their annual electricity demand with PV. PV represents around 3 % of the global electricity demand and 5% in the EU.

The contribution of PV to decarbonizing the energy mix is progressing, with PV saving as much as **720 million tons of CO_2eq**. At the end of 2019, PV contributed to reducing global CO_2 emissions by 1,7% or 2,2% of the energy-related emissions and 5,3% of the electricity related emissions, compared to a world without PV. 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 - 2020
TOP PV MARKETS 2019
CHINA 30,1 GW
EU 16,0 GW
USA 13,3 GW
115 GW
GLOBAL PV MARKET
15%
57%
18%
7%
3%
The Americas
Asia Pacific
Europe
Middle East and Africa
Rest of the World
CO2eq
720 Mt
CO2 emissions
avoided in 2019
627 GW were installed all over the world
by the end of 2019
China is the world's #1 PV market
18 countries installed at least 1 GW
of PV in 2019
9 countries have installed at least 10 GW
of cumulative capacity at the end of 2019
SOLAR PV PER CAPITA 2019 Watt/capita
1st GERMANY 595
2nd AUSTRALIA 585
3rd JAPAN 497
COUNTRIES WITH HIGHEST PV PENETRATION
Honduras 14,8%
Israel 8,7%
Germany 8,6%
Chile 8,5%
Australia 8,1%
Greece 8,1%
Japan 7,6%
Italy 7,5%
India 7,5%
Belgium 5,7%
Netherlands 5,6%
0% 2% 4% 6% 8% 10% 12% 14% 16%
3,0% OF
THE WORLD'S ELECTRICITY GENERATION IS COVERED BY PV
EVOLUTION OF ANNUAL PV INSTALLATIONS
GWp
120
100
80
60
40
20
0
2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
IEA PVPS Countries
Non IEA PVPS Countries
European Union
USA
Japan
China
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1 SNAPSHOT OF THE GLOBAL PV MARKETS IN 2019

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 ninth edition of the "Snapshot of Global PV Markets" aims at providing **preliminary information** on how the PV market developed in 2019. The 26th edition of the PVPS complete "*Trends in Photovoltaic Applications*" report will be published in Q4 2020.

In 2019, the PV market broke the 100 GW threshold for the third time in a row and the market grew 12% YoY. This growth follows a year of stabilization and is explained by the significant market increase in all continents, which global effect has been partially hidden by the slowdown in China, the world market leader in PV installations. Indeed, for some years, the level of market development in China has been driving the global PV market to a large extent. With around 30,1 GW installed in China in 2019, compared to 43,4 GW in 2018 and 53,0 GW in 2017, the global PV market increased to 114,9 GW compared to 102,2 GW in 2018 and 103,4 GW in 2017.

Behind China, the European Union ranked second with around 16,0 GW of annual installations in 2019. The USA follow with an increased market at 13,3 GW, followed by India that contracted slightly at 9,9 GW. Japan closes the top five with an estimated 7 GW, a stable level compared to 2018.

The top five remained similar as in 2018 with a change in standing. Behind these countries, some changes occurred in 2019: Vietnam installed 4,8 GW for the very first time, followed by a booming Spanish market at 4,4 GW; Australia installed an expected 3,7 GW while Ukraine follows with 3,5 GW. Looking a bit more in depth at European Union countries, Germany experienced another growth year, with about 3,9 GW installed and the Netherlands continue massive installations with 2,4 GW commissioned during the year.

Asia continues to dominate the global PV market despites the Chinese market slowdown. Some already established major Asian markets, such as Korea, Taiwan or Malaysia, experienced a growth in 2019, while China and 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, but it is unsure whether such an installation level will be sustained. Asian markets represented around 57% of the global PV market in 2019, a significant decrease compared to levels experienced in previous years.

In the Americas, the market increased slightly, mainly through the US market which experienced accelerated growth (13,3 GW) in 2019. Brazil is the second market with around 2,0 GW installed in 2019, followed by Mexico which installed around 1,0 GW in 2019. Chile installed 700 MW, a relatively stable growth and Argentina installed around 500 MW, a record level. The market in Canada was quite low with around 200 MW installed in 2019. The Americas represented around 16% of the global PV market in 2019.

In the European Union, Spain boomed thanks to the tenders with 4,4 GW after years of market stagnation; Germany came in the second position with 3,9 GW, a significant increase for the third year in a row. The Netherlands with 2,4 GW experienced for the second time a significant market development, followed by France still below the GW mark at 0,9 GW. Italy progressed around 0,6 GW and Belgium installed 544 MW. The ranking continued with Switzerland (352

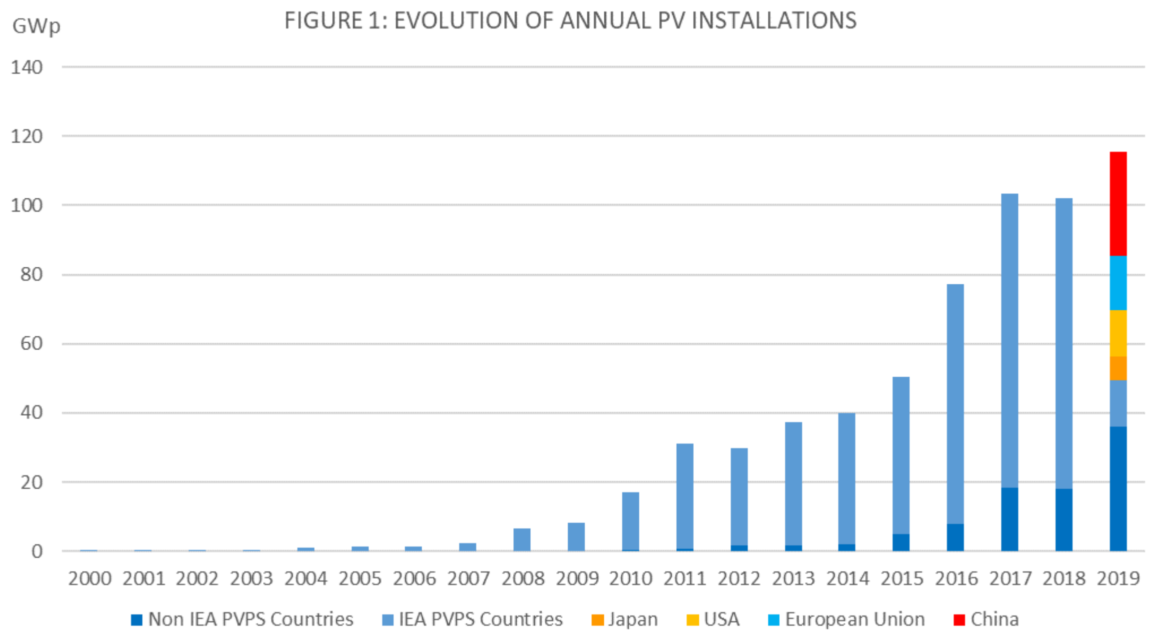
MW), Sweden (287 MW), Austria (224 MW), Portugal (150 MW), Denmark (104 MW), Finland (77 MW) and Norway (50 MW).

Other countries in Europe, especially in the eastern part of the continent, experienced interesting developments: Ukraine with 3,5 GW, Poland (around 800 MW), Hungary (around 900 MW). The UK stayed at a very low level as compared to previous years (233 MW) while Greece progressed for the first time in years (around 250 MW). Europe as a whole represented slightly more than 18% of the global PV market in 2019.

In the Middle East, Israel installed an additional 1,1 GW, the highest performance in years. In the United Arab Emirates around 2 GW of projects came online (with some installed in 2018 but commissioned in 2019), mainly due to tenders in the previous years. In Jordan, several projects that were in the pipeline came online in 2019, for a total of 600 MW. Turkey installed 0,9 GW, a major decline for the second year in a row.

In Africa, South Africa installed 1 GW; Egypt installed at least 1,7 GW in 2019 and the market developed in Morocco at a lower level: the country topped 200 MW of PV at the end of 2019.

Africa and the Middle East represented around 8% of global PV installations in 2019.



Source: IEA PVPS

Overall, the global PV market crossed the 100 GW mark for the third year in a row. Despite the lower market level in China, the global market increased thanks to the growth of the market outside China which accounted for more than 44%, a significant increase compared to 17% in previous years.

In 2019, at least 18 countries passed the GW mark with respect to the annual installed PV capacity, eight more than in 2018. Nine countries now have more than 10 GW of total cumulative capacity, five have more than 40 GW and China alone represented 204,7 GW. The European Union (as EU28), which used to lead the rankings for years, lost its leading position in 2015 and now ranks second (131 GW), with the USA third (75,9 GW) and Japan fourth (63 GW).

2 THE TOP 10 MARKETS IN 2019

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

The dynamics of the PV market remain visible, with new countries entering the top 10 this year (Vietnam and Ukraine) and usual market leaders comforting their position, The European Union soared into second place, ahead of the USA and India.

Several countries which in previous years installed significant capacities have left the top 10 for annual installed capacities, such as France, the Netherlands and Turkey. Those country still experienced significant market developments, however, not enough to stay in the top 10 in 2019.

The top 10 of total cumulative installed capacities shows more inertia due to past levels of installations: Italy or UK have left the top countries for a long time, but their past developments still allow them to stay in the top 10 for total 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 2019

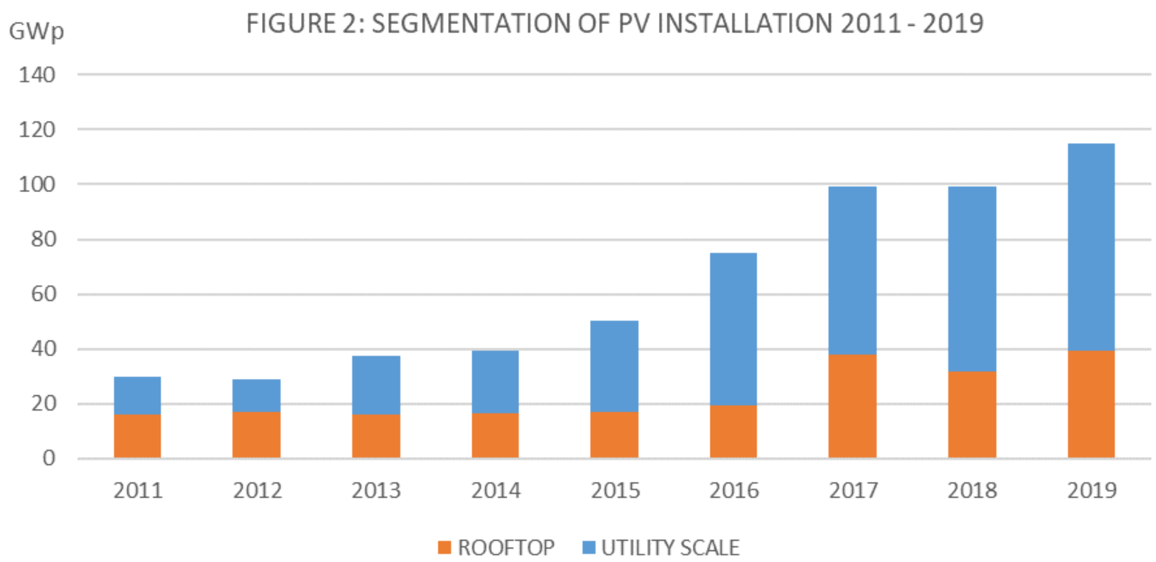
FOR ANNUAL INSTALLED CAPACITY			FOR CUMULATIVE CAPACITY		
1	China	30,1 GW	1	China	204,7 GW
(2)	*European Union*	*16,0 GW*	(2)	*European Union*	*131,7 GW*
2	United States	13,3 GW	2	United States	75,9 GW
3	India	9,9 GW	3	Japan	63 GW
4	Japan	7,0 GW	4	Germany (EU)	49,2 GW
5	Vietnam	4,8 GW	5	India	42,8 GW
6	Spain (EU)	4,4 GW	6	Italy (EU)	20,8 GW
7	Germany (EU)	3,9 GW	7	Australia	14,6 GW
8	Australia	3,7 GW	8	UK (EU in 2019)	13,3 GW
9	Ukraine	3,5 GW	9	Korea	11,2 GW
10	Korea	3,1 GW	10	France (EU)	9,9 GW

Source: IEA PVPS

* The European Union grouped 28 European countries in 2019, out of which Spain, Germany, Italy and the UK appear in the Top 10. The UK quit the EU in 2020 but is still counted in 2019 numbers reported here. The UK did not change positions in either of the rankings.

3 AC OR DC NUMBERS AND MARKET SEGMENTATION

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 in Germany 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 2019 have an DC-AC 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.



Source: IEA PVPS

Preliminary data show that the distributed PV market slightly increased in absolute numbers compared to 2018. However, it relatively diminished compared to the centralized PV market. The utility-scale market grew in 2019 in absolute numbers, due to a strong push from tendering schemes in many countries.

The market has also started to diversify, with floating PV adding to utility-scale and BIPV starting to complement BAPV in the built environmental. 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.

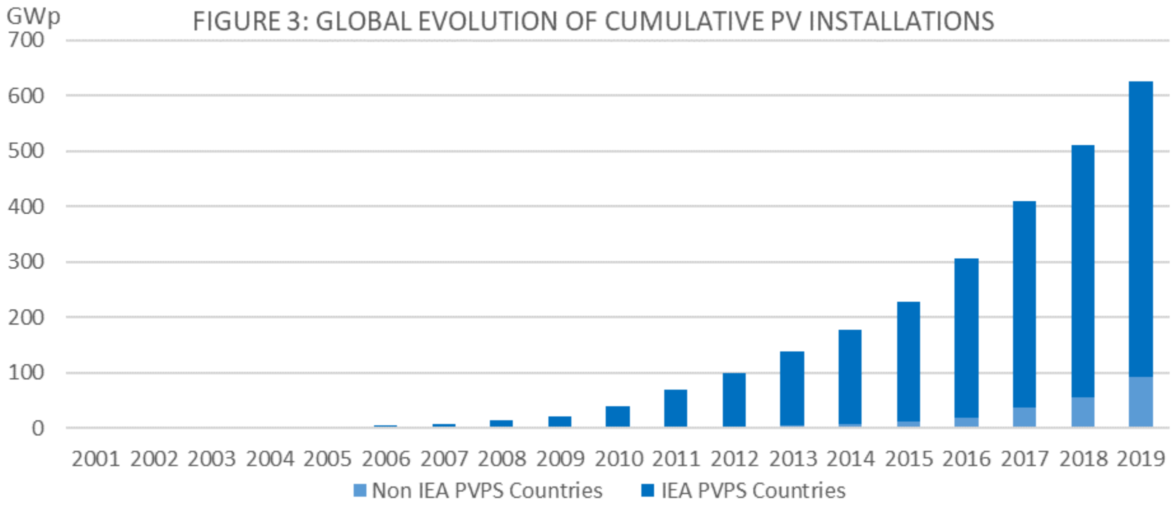
4 CUMULATIVE INSTALLED CAPACITY IN THE WORLD

As illustrated in Figure 3, the total cumulative installed capacity at the end of 2019 globally amounted to at least 627 GW. China continues to lead with a cumulative capacity of 204,7 GW, followed by the European Union (131,3 GW), the USA (75,9 GW), Japan (63,0 GW) and India (42,8 GW). In the Asia-Pacific region, Australia reached 14,6 GW and Korea 11,2 GW. In the European Union, Germany leads with 49,2 GW, followed by Italy (20,8 GW) and the UK (13,3 GW). All other countries are below the 10 GW mark.

The IEA PVPS countries represented 534,5 GW of cumulative PV installations together, mostly grid-connected, at the end of 2019. 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 92,1 GW cumulative installed capacity at the end of 2019: India with at least 42,8 GW, Vietnam with 4,9 GW, Ukraine with 4,8 GW, Taiwan with 4,1 GW and more: Several GW have been installed in Pakistan, Brazil, Egypt, the UAE, Jordan and Russia. PV has been installed at various levels in all countries in the world, but most are counting installations in MW rather than GW.

At present, it appears that 617,2 GW represents the minimum installed by end 2019 with a firm level of certainty in the IEA PVPS countries and the other major markets. Remaining markets account for an estimated additional 9,8 GW that could bring the total cumulative installed capacity to around 627 GW.



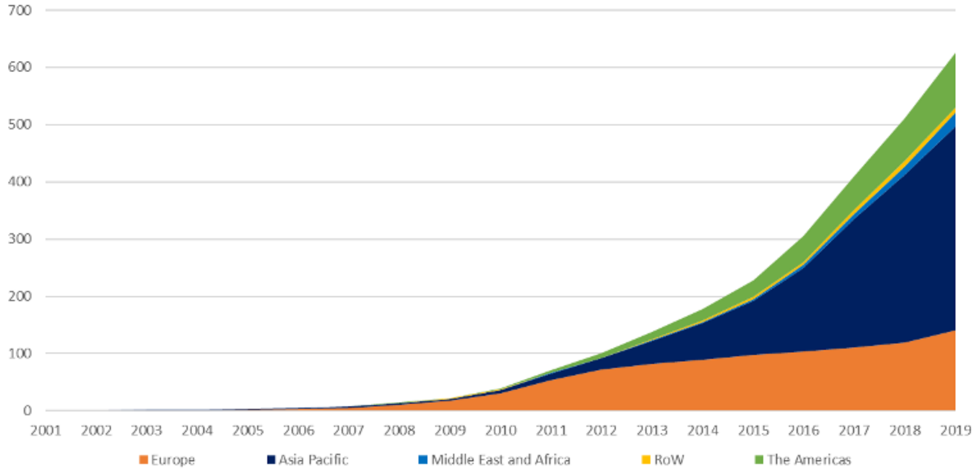
Source: IEA PVPS

5 REGIONAL CUMULATIVE INSTALLED PV CAPACITY

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 4). Driven by China, India, Japan, Korea and more, Asia represented around 57% of the total cumulative installed capacity in 2019, a significant decrease due to the Chinese market slowdown. With the fast growth of the Asian market, Europe is losing its share year by year, however in 2019 the European market reexperienced a significant growth. At the end of 2019, 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, while the remaining 6% came from the MEA region and the rest of the world (unidentified installations).

Increasingly, PV capacities start to represent the wealth and population distribution better. Wealthy countries largely initiated market development while larger countries expanded it. The market follows the electricity demand more closely and it will reach weaker economies in the coming years.

FIGURE 4: EVOLUTION OF REGIONAL 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 don't track properly 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 operations' business, but in general it doesn't 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.

6 ELECTRICITY PRODUCTION FROM PV

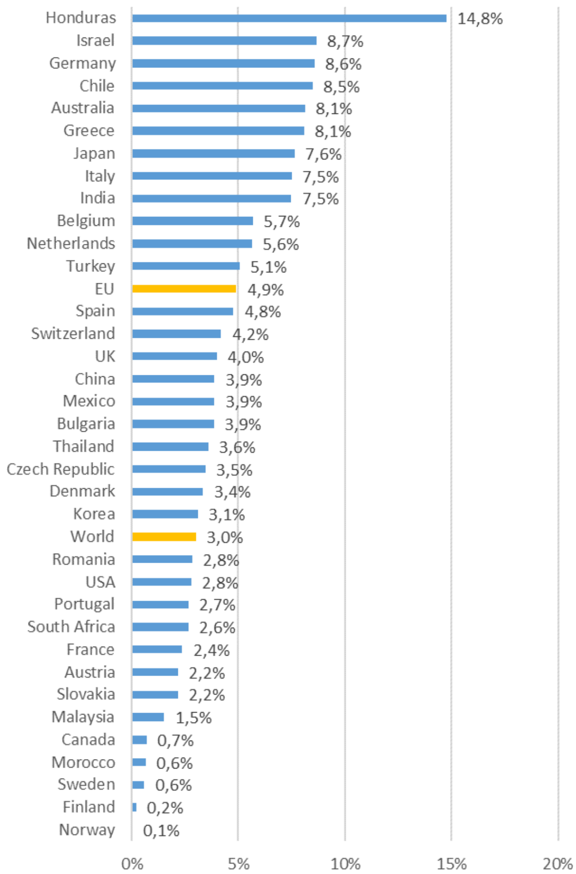
PV electricity production is easy to measure for an individual power plant but much more complicated to compile for an entire country. In addition, the comparison between the installed base of PV systems in a country at a precise date and the production of electricity from PV is difficult to compare. 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. Furthermore, the weather can show some significant differences from one year to another. 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 2019, close to optimum siting, orientation and long-term average weather conditions.

Figure 5 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 2019. Since these numbers are estimates based on the total cumulative capacity at the end of the year 2019, 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 the first place with almost 15%. Israel is second with an estimated 8,7% and Germany third with a theoretical penetration level of 8,6%.

In total, PV contribution amounts to close to 3,0% of the electricity demand in the world and close to 5,0% in the European Union.

FIGURE 5: THEORETICAL PV PENETRATION 2019



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 electricity prices, around 20 USD/MWh in the sunniest places, and even below in the Middle East for instance. The decreasing price trend continues, and most believe prices will continue to go down in the coming years, probably at a more stable pace. In places with limited or no incentives, tenders are going through the floor and setting new standards for PV competitiveness.

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

Merchant PV, with PV electricity sold on electricity markets has been seen in 2019 in several countries, 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 and could inundate the world with cheap electricity.

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 the USA, Canada, Denmark, the Netherlands, Portugal, Korea and partially in Belgium, 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 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, Sweden, France, Switzerland and in Germany. In Italy, PV systems connected through a private transmission line to a single end user are allowed under specific conditions, and several countries are testing the concept. 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.

Recently, the European Union introduced the concept of Renewable Energy Communities (REC). REC should allow citizens to sell renewable energy production to their neighbours, 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 themselves in a solar installation.

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

In 2019, most of the PV markets did not experience abrupt or unannounced retroactive measures and the situation has therefore improved compared to previous years. However, retroactive measures in recent years considerably decreased investor's confidence in the PV market and still have an impact on the level of installations, even when the market conditions are favourable. The most important changes took place in Spain; despite that the infamous Solar Tax was abandoned last year, the imposed retroactive measures to PV system owners will stay in place. These measures reduced in some cases the revenues of PV system owners by 50%. In Italy, in order to reduce the impact of PV costs to the electricity consumers, the government imposed in 2014 a decrease of the FiT level compensated by an increase of the payment years.

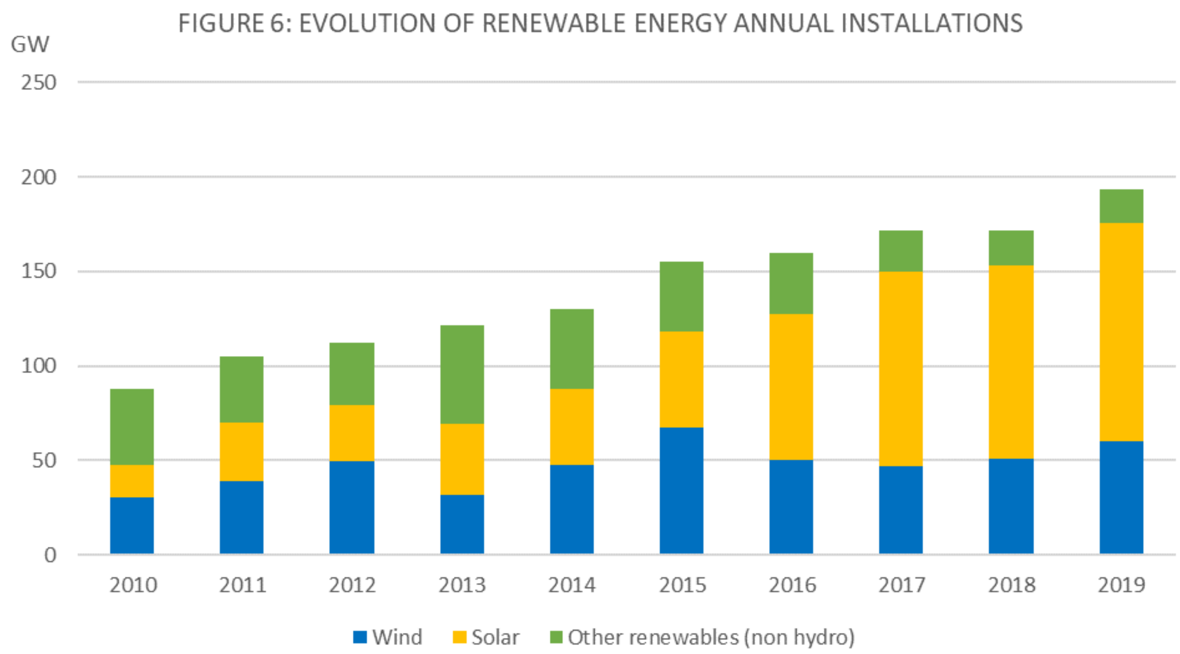
Other countries also applied retroactive measures that reduced the level of financial support or changed the conditions applying to already existing PV systems. Bulgaria, Romania and the Czech Republic have discussed or applied such measures in the last three years, often with the consequence of destroying investors' confidence and bringing down the PV market. In Belgium, retroactive measures were integrated in the law granting green certificates, which legally allowed a decrease of the number of years during which the certificates were granted. Some Belgian regions also implemented or tried to implement specific taxes for existing prosumers' installations under the justification of financing the grid.

These measures, sometimes legally justified, have significantly decreased the confidence of investors and in all cases reduced the PV markets mentioned above. The biggest barrier to PV development for prosumers is now the fear that self-consumption or net-metering policies already granted could be changed, downgraded or taxed for existing PV installations. 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

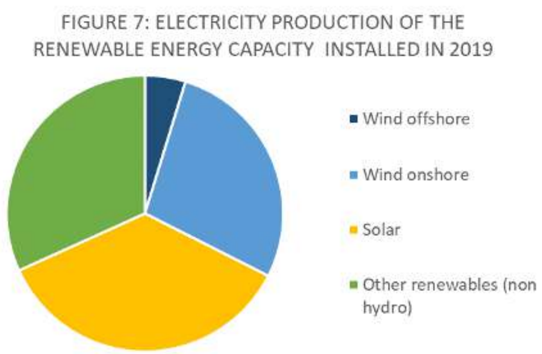
8.1 PV and Other Renewable Energy Evolutions

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 in Figure 6. In the last 15 years, PV technology has shown an ever-increasing market growth thanks to technology and price development. In these recent years, 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.



Sources: compilation of IEA PVPS, GWEC, IRENA and estimations for 2019

In 2019, solar PV stood for approximately 59% 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.



Sources: IEA PVPS, GWEC and estimations for 2019

8.2 Impact of PV Development on CO2 Emissions

Global energy related CO_2eq emissions have been around 33 Gt in 2019, flattening after two years of increase and the record value of 2018. A main reason for this has been the decline in CO_2 emissions from the power sector in advanced economies, thanks 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 13 Gt of CO_2eq in 2019, a slightly lower level as 2018 (1,2% lower).

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 2019, around 720 Mt of yearly 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 5,5% of the total power sector emissions.

8.3 PV Fostering Development of Clean Transport

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.

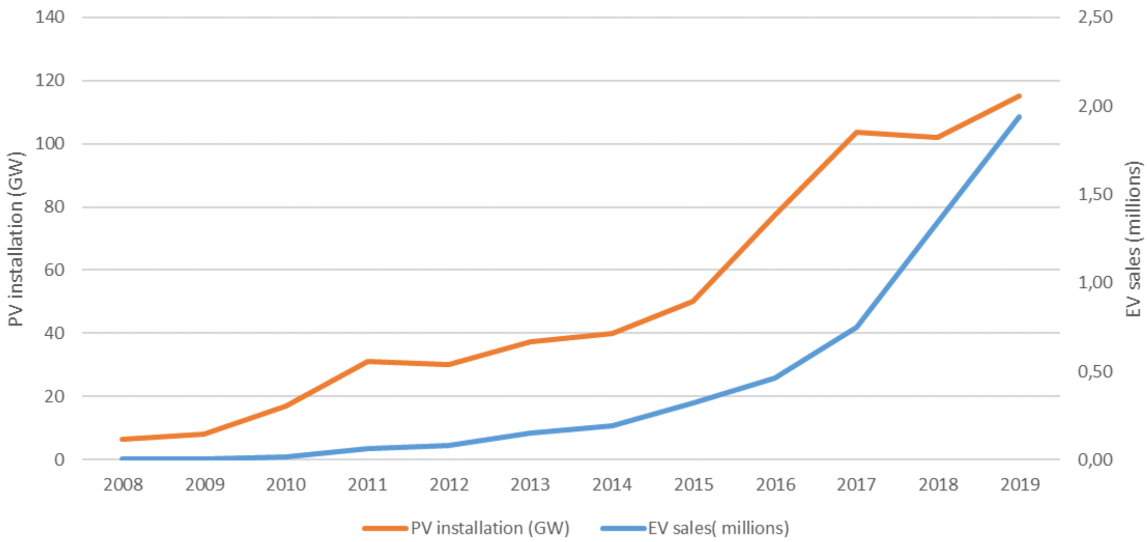
One key technology for the energy transition, also when it comes to seasonal storage is probably green hydrogen production. After years of research and pilot projects, the first commercial hydrogen plants are being built all over the world:

- 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 the south-east of France. It aims to produce 1 300 GWh of photovoltaic electricity by 2027. 600 GWh of electricity will power electrolysers in order 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 10 000 kW 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, some hydrogen-powered trains have been introduced to replace diesel engines. The shift to clean energy continues as more hydrogen-powered trains will go into service starting in 2021. A national hydrogen roadmap was published by the government of research in November 2019.
- 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 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 almost 2 million electric vehicles sold in 2019 alone, the penetration of EVs is likely to breakthrough more quickly than PV did initially.

FIGURE 8: EVOLUTION OF EV AND PV ANNUAL GROWTH



Source: IEA until 2018 and compilation of official national sources or estimates for 2019

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