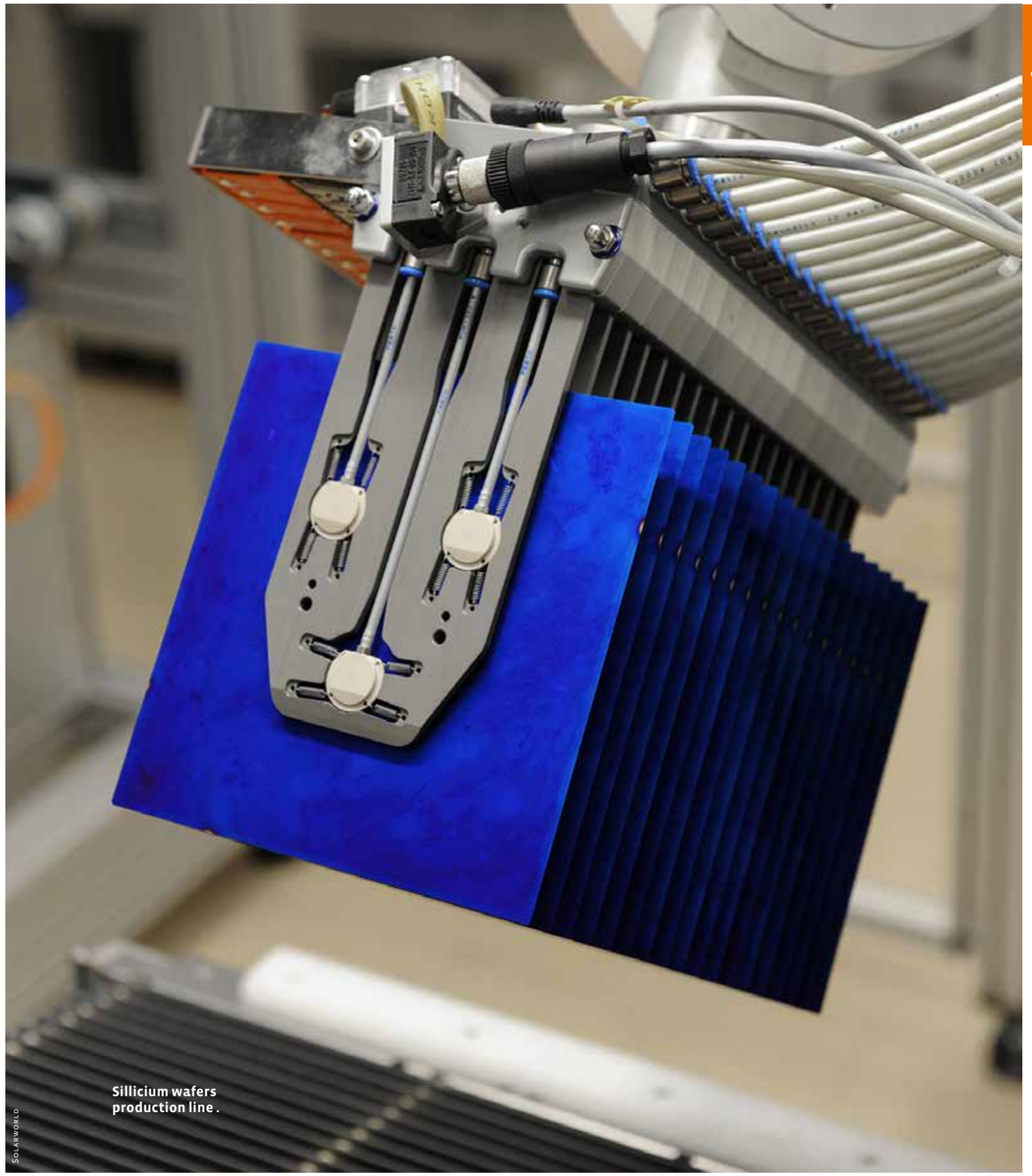

Sillicium wafers production line.

SOLARWORLD

114 549 MW

Cumulative photovoltaic capacity in the European Union at the end of 2018

PHOTOVOLTAIC BAROMETER

A study carried out by EurObserv'ER

The global photovoltaic base continues to make inroads across the five continents. At the end of 2018, its capacity exceeded half a million megawatts, which equates to about 100 GW of newly-installed capacity. In 2018, China's market faltered, while there was a revival in the European Union market and the emerging markets picked up steam.

122.3 TWh

Photovoltaic electricity generated in the EU in 2018

7 606.5 MW

Photovoltaic capacity connected in the EU during the year 2018

PHOTOVOLTAIC BAROMETER – **EUROBSERV'ER** – APRIL 2019

TIMOTHEE BONGRAIN/OBSERVER

Topaz Solar Farm in California.

Deployment of the global photovoltaic market in 2018 was more restrained than in 2017 because of changes in direction made by the policy makers of the world's largest markets. The key measures were the swingeing subsidy cuts in the Chinese market that were compounded by the customs duties levied on cells and modules by both the United States and India. This contrasts with the European Commission's 3 September 2018 decision to curtail the anti-dumping measures that it had applied to Chinese cells and modules. The move had the effect of boosting its market. Lastly, as module prices fell, deployment of solar power in emerging markets gained new momentum.

IN 2018 THE GLOBAL MARKET STOOD AT AROUND 100 GW

The main international organizations' and specialist consultants' first estimates for 2018 do not concur on a clear global photovoltaic market trend. While they all pitch their figures at around 100 GW with similar installation levels to 2017, some interpret them as a slight drop, while others view them as a slight rise. The most recent data published on 15 April 2019, by the IAE-PVPS experts (International Energy Agency-Photovoltaic Power Systems Programme) suggest 99.8 GW of new capacity was installed (compared to 98.9 MW in 2017), confirming stable connection figures. If the 2017 global installed base data is taken as the reference figure (403 GW), capacity must have crossed the threshold of half a million MW installed. It should be recalled that in 1998, according to the IAE-PVPS statistics, photovoltaic capacity peaked at 234 MW. Thus, we can see how far solar photovoltaic has come in twenty years. These same IAE-PVPS experts now reckon that solar photovoltaic contributes 2.6% of global electricity output but point out that it has the potential to become a major worldwide source of electricity in a very short timescale.

Turning to general trends, the Chinese market limited its market contraction to about 45 GW and the slowdown has been offset by increased volumes in the established and a few emerging markets **(table 1).** The growth markets include India, which installed 10.8 GW in 2018, Australia with 3.8 GW of growth, closely followed by South Korea (2 GW). The Turkish market lost some of its shine (1.6 GW). The African and Middle-Eastern markets also expanded, but the experts anticipate better growth in 2019 when major solar farms are due to be commissioned in Egypt and the United Arab Emirates. The European market, assisted by high growth in Germany and the Netherlands, has picked up, with very interesting growth prospects for the next two years (see further on).

The trend for 2019 seems much clearer, and the main analysts agree that growth will be strong. According to IHS Markit, the market should expand by 25% to reach a volume of 129 GW. This optimism is based on the sharp drop in solar module prices at the end of 2018 and on a hike in demand outside China. The European market should continue to benefit from the end to minimum import prices for Chinese equipment, while the US market should be boosted by the last year of eligibility for the 30% investment tax credit (ITC). EnergyTrend reckons that next year, the market could expand by 7.7% to 111.3 GW and that Europe could enjoy the highest growth. Photovoltaic Market Alliance experts are counting on 20% growth to 120 GW and even predict that the market will double by 2022 to 200 GW, through the development of new applications such as floating solar farms, the agrivoltaic sector, solar vehicles and a much more buoyant building-integrated photovoltaic (BIPV) market.

CHINA AND UNITED STATES ARE STILL OUT IN FRONT

2019 – the year of network parity for China

The most significant event of the 2018 photovoltaic market was the Chinese market slide. China now accounts for less than half of the global market. The official figures released in January by the National Energy Administration (NEA) claim that China had 174.63 GW of on-grid solar photovoltaic capacity at the end of 2018, which is 33.9% more than in 2017 (130.25 GW). These figures assume that on-grid capacity increased by 44.38 GW over the twelve-month period (compared to 52.8 GW during 2017), which is an 8.42 GW drop in annual connection capacity (or 16% less than in 2017).

The reason for this market slide is the government's decision, taken without warning on 31 May 2018, to grant no further commissioning licences for any new major power plants until the end of the year, at the same time slashing the regulated Feed-in Tariffs for existing power plants (by about 0.05 yuan per kWh, which depending on the regions was 6–9%). Since the start of 2019, licenses have been awarded to large-scale energy solar projects, but the government is banking on granting very much less funding to the sector.

A warning shot was fired at the start of the year when a new specific subsidy-free "network parity" mechanism was created under which connection licences for large ground-based plants are directly awarded to power plants capable of matching or undercutting the coal-fired power plant electricity price. No installation quota applies to these plants for at least the next two years. However, subsidy-free project licences will only be delivered in interconnected zones where full use of the generated electricity is guaranteed. Local provincial governments will still be free to grant subsidies, but only to projects currently being developed in their region. Subsidy-free projects should not immediately generate major flows but will rapidly gather momentum. According to the Citygroup Research consultants, given the expected drop in module prices, network parity with coal-fired plants should be achieved from this year in 11 of China's 31 administrative provinces. In December 2018, the first such power plant (500-MW) was connected in the city of Golmud, in Qinghai province, on the Tibetan plateau, at a sales price of 0.316 yuan per kWh, which is lower than the 0.325 yuan per kWh coal-fired power plant market price. The government and sector players are looking into setting up a reverse auction system for projects not covered by this mechanism, whose construction licences are awarded to the cheapest projects.

Solar is tipped to surge in the United States

Conditions were tough for solar photovoltaic in the United States in 2018, for the Trump administration announced in 2017 that from 7 February 2018 customs duties would be levied on cell and module imports, creating a period of uncertainty as installations dried up. The duty (expressed as a percentage of the value of the incoming goods) was set at 30%. It will decrease by 5 percentage points per annum for four years. So, in 2021 it will be levied at 15%, after which the tariff will expire unless the measure is extended. An annual quota of 2.5 GW of cells is exempt from the duty so as not to penalize American module manufacturers who do not produced their own cells. Despite the turmoil, strong acceleration

Tabl. n° 1

Capacity installed in 2018 by the main non-EU photovoltaic markets

Countries	Newly added capacity in 2018 (GW)
China	44.4
USA	10.6
India	10.8
Japan	6.5
Turkey	1.6
Australia	3.8
Mexico	2.7

Sources : AIE PVPS, NEA

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KLAUS LEIDORF/SUNPOWER

Solar plant located in Muhlhausen, Germany

in the connection pace during the last quarter, enabled the American market to hold good. The joint report released by the Wood Mackenzie and Solar Energy Industries Association (SEAI) analysts appraised installed capacity at 10.6 GW in 2018, which is a 2% slip on the 2017 installation level, while Bloomberg NEF analysts announced 6% or 11.7 GW growth (11 GW in 2017).
A return to robust growth in the United States is expected shortly. Wood Mackenzie reports that the United States ended the year with at least 23.9 GW of high-capacity power plant projects under power purchase agreements (PPA), including 2.6 GW that was already under construction at the end of 2018. Wood Mackenzie has identified a further 42 GW of projects announced that are pending approval in addition to the projects that have already secured funding. The specialist PV Magazine count suggests that applications for at least 139 GW of projects have been filed with 6 grid operators. While some of them are speculative and are unlikely to come to fruition, it is quite clear that solar photovoltaic installations should reach new heights in a few years' time.

Activity picks up in the European market

Newly-connected solar capacity in the European Union shot up in 2018. According to the data collected by EurObserv'ER, 7606.5 MW of on-grid capacity was added across the EU, which is a 33.7% improvement on 2017 **(table 2).** The European base in service now amounts to 114 549 MW **(table 3).** This recovery signals that the transition to market mechanisms for large power plants has been completed. At the end of the year the market also began to take advantage of the September abolition of anti-dumping taxes levied against Chinese modules and cells by the European Commission. The full effect of this U-turn should be felt in 2019 and 2020.
Lower module prices and regular publication of tenders in the main European solar markets (Germany, Netherlands, France) have brought new momentum to the sector. Photovoltaic is also taking up the strong self-consumption trend in the residential and collective sector enhanced by the announced increase in Europe electricity prices. The fact that the European market can again stand on its own two feet, through ground-based power plants and distributed solar power (residential solar power and roof-mounted panels), will enable it to progress much faster.

122.3 TWh generated in the European Union

In 2018 the solar resource was poorer than in 2017 in Southern Europe with lower load factors in Spain (dropping from 1 802 to 1 638 hours) and Italy (from 1 184 to 1 086 hours). This contrasted with slightly more sunshine in the northern half of Europe with higher load factors registered in Germany (rising from 931 to 1020 hours) and the UK (from 937 to 998 hours). All in all, preliminary official estimates suggest that European Union output should reach 122.3 TWh in 2018, or a 7.8% improvement on 2017 **(table 4).**

In 2018 solar photovoltaic accounted for 3.7% of the European Union's gross electricity output (3.4% in 2017) and overtook the Netherlands' gross electricity output. The solar power shares of a few countries like Germany and Italy have already passed the 7% mark (7.1% in Germany, 7.6% in Italy).
A few countries with self-consumption-friendly policies monitor the directly self-consumed share of solar power. For example, Italy's grid operator Terna puts it at 22.6% for 2018 (20.4% in 2017), the Portuguese Directorate-General of Energy and Geology recorded 16% (18% in 2017) and the AGEE-Stat the Working Group on Renewable Energy Statistics recorded 10.8% in Germany (10.1% in 2017).

Almost 3 GW more in Germany

The German solar photovoltaic market continued to recover, and this time with more confidence. According to AGEE-Stat, Germany connected 2 938 MW to the grid in 2018 compared to 1 625 MW in 2017, which amounts to an 80.8% improvement. Three-quarters of this capacity is roof-mounted while the remaining quarter is generated by ground-based photovoltaic power plants. By the end of 2018 the German installed solar panel base stood at 45 277 MW spread across some 1.7 million installations that alone account for almost 40% of the European Union's installed photovoltaic capacity. The country is also in the lead for per capita photovoltaic capacity (546.9 W PC), a long way ahead of Belgium (373.2 W PC) and Italy (332.4 W PC) **(graph 1).**
The government, keen on meeting its climate targets, decided to launch a series of tenders to accelerate the deployment of solar photovoltaic. These supplement those already scheduled by law for ≥750 kW installations to achieve a combined volume of 4 GW by 2021. The first "special" tender results for 500 MW of power demand (closed on 1 March) were published early in April. One hundred and twenty-one projects were selected for a total capacity of 505 MW. The mean reference price obtained is € 65.9 per MWh, which is much higher than the mean reference price obtained during the last regular tender which closed on 1 February 2019 and that was pitched at € 48 per MWh for the 178 MW retained. This rise cannot be dismissed as being for lack of bids, because once again there were many proposals – 163 applications filed for a combined capacity of 870 MW. In a press release dated 28 March 2019, the grid network agency (Bundesnetzagentur) president Jochen Homann explains "there always seem to be sufficient solar projects in the pipeline to absorb the additional volume planned in the recent energy law and ensure competitive bidding". However, the fact remains that like the wind energy sector, Germany's level of solar energy development makes access to the lands in the south with the best exposure more difficult, with speculation on the lands still available. The sector also decries the fact that the recent tenders limited the size of solar farms to 10 MW, which reduces the available economies of scale. The increase in bids may

Tabl. n° 2

Photovoltaic capacity installed and connected in European Union during the years 2017 and 2018 (in MW)*

	2017	2018
Germany	1 625.0	2 938.0
Netherlands	854.0	1 397.0
France**	908.4	862.4
Italy	399.0	440.0
Hungary	109.0	410.0
Belgium	284.6	367.2
United Kingdom	871.0	271.0
Poland	99.8	214.0
Sweden	91.0	180.1
Austria	173.0	164.0
Denmark	55.3	95.7
Portugal	72.2	86.0
Finland	39.0	51.0
Greece	1.5	46.1
Spain	9.0	26.0
Malta	19.3	19.0
Ireland	9.8	13.3
Slovenia	13.8	9.2
Luxembourg	10.2	5.9
Cyprus	26.0	3.0
Slovakia	0.0	3.0
Romania	2.1	2.9
Croatia	4.0	1.0
Bulgaria	7.6	0.4
Latvia	0.0	0.3
Lithuania	4.0	0.0
Czechia	1.5	0.0
Estonia	0.0	0.0
European Union	5 690.1	7 606.5

Estimates, off-grid included* ***Overseas departments included for France.* ***Source : EurObserv'ER 2019*

be partly explained by the fact that many projects that have been filed (17 projects for 192 MW) were rejected on technicalities. More recently, on 18 April 2019, the grid agency unveiled the third bi-technology tender results combining solar with wind energy for a target capacity of 200 MW. As in the two previous tenders, solar projects were the only ones to bid successfully. The total volume allocated is 210.8 MW, with a mean reference price of € 56.60 euros per MWh (in the range € 45–61 per MWh), slightly higher than € 52.70 euros per MWh (in the range € 46.5–57.8 per MWh) reference price of the 2nd bi-technology tender divulged last November. Although they are slightly higher, the average prices observed were much lower than those of the "special" tender. The bi-technology procedure was again over-subscribed with 109 applications filed and about 720 MW of combined capacity. Yet again, the applications were only for solar projects, which confirms that this sector offers the most competitive renewable energy source.

Tenders are not required for <750-kW photovoltaic installations. In the <100 kW range, they are subject to a Feed-in Tariff regime, which is revised monthly. The installation type- and size-dependent Feed-in Tariff calculated for April 2019 breaks down from € 0.07 to € 0.1111 per kWh. Direct sales are compulsory for ≥100 kW installations and the operators are awarded top-up remuneration (Marktprämie). The reference value for direct sales is also installation type- and size-dependent. From 1 April 2019 onwards, it is set at € 0.0808–0.1151 per kWh.

Germany enjoyed a particularly sunny year in 2018, and its load factor rose from 931 to 1 020 hours. This combined with the increase in installed capacity, pushed electricity output to 46.2 TWh, which is a 17.2% year-on-year increase. According to AGEE-Stat, the directly self-consumed electricity share continued to rise and reached 10.8% in 2018 (10.1% in 2017 and 9.5% in 2016). The self-consumption market is increasingly linked to the storage market. The German Solar Association (BSW) claims that the photovoltaic battery system market was about 35 000 units in 2018 (20 000 in 2016, 31 000 in 2017). The figure means that just under one out of every two installations is equipped with an electricity storage system (76 500 new installations in 2018). The same source puts the combined battery-equipped solar installation base at 120 000 units at the end of 2018, remembering that the storage market only really took off in 2013.

The Dutch market sails past the 1-GW mark

In 2018, the Dutch photovoltaic market was particularly buoyant. According to Statistics Netherlands, it connected 1 397 MW, which is a 63.6% improvement on its 2017 connection performance of 854 MW. The country's total capacity at the end of 2018 amounted to 4 300 MW. The connection of very high-capacity projects funded under the SDE+ programme fuelled this strong growth along with its very active residential photovoltaic market. However, at the end of 2018, the Dutch Ministry of Economic Affairs and Climate Change announced that the budget allocated to the SDE+ programme aimed for >15-kW solar and renewable energy projects would fall from 12 to 10 billion euros. According to Peter Segaar, a solar energy analyst interviewed by PV Magazine, activity is likely to decline as a result of this budget cut despite the expected drop in module costs. Nonetheless, the volume that has already been secured will enable several GW of capacity to be connected in the next few years.

As for the residential and commercial sectors, the project to transform the "net metering" invoicing system into a grant system for surplus generated electricity planned for 2020 (called the "terugleversubsidie" system) may be postponed until 2021 because the relevant administrative procedures are overly complex. Under this new system, investors will be exempt from energy taxes for the part of the electricity they self-consume, and from the ODE (Opslag Duurzame Energie) contribution – a tax on electricity consumption that finances renewable energy programmes.

Peter Segaar thinks the high growth of the residential net metering market segment is set to continue, boosted by

Tabl. n° 3

Connected and cumulated photovoltaic capacity in the European Union countries at the end of 2017 and 2018 (in MW)*

	2017		2018	
	Total	Of which off-grid	Total	Of which off-grid
Germany	42 339.0		45 277.0	
Italy	19 682.0		20 107.0	
United Kingdom	12 783.0		13 054.0	
France**	8 610.4		9 466.0	
Spain	4 725.0	30.0	4 751.0	34.0
Netherlands	2 903.0		4 300.0	
Belgium	3 610.0		4 254.5	
Greece	2 605.5	160.5	2 651.6	160.5
Czechia	2 069.5		2 048.9	
Austria	1 269.0	7.0	1 433.0	8.0
Romania	1 374.1		1 377.0	
Bulgaria	1 035.6		1 036.0	
Denmark	906.3		1 002.0	
Hungary	344.0		754.0	
Portugal	585.0	41.0	671.0	55.0
Slovakia	528.0		531.0	
Poland	287.0		486.5	
Sweden	244.0	13.0	424.1	13.0
Slovenia	246.8		256.0	
Luxembourg	132.1		134.0	
Malta	112.3		131.3	
Finland	74.0		125.0	
Cyprus	110.0		113.1	
Lithuania	74.0		74.0	4.0
Croatia	60.0		61.0	
Ireland	15.7	15.7	29.0	29.0
Latvia	0.7		1.0	
Estonia	0.0		0.0	
European Union	10 6726.1	271.2	11 4548.9	303.5

Estimates, accounting capacity decommissioned. **Overseas departments included for France.* ***Source: EurObserv'ER 2019*

Tabl. n° 4

Electricity production from solar photovoltaic power in European Union in 2017 and 2018 (in TWh)

	2017	2018
Germany	39.401	46.164
Italy	24.377	22.654
United Kingdom	11.525	12.922
France	9.573	10.196
Spain	8.514	7. 785
Greece	3.991	3.791
Belgium	3.288	3.563
Netherlands	2.204	3.152
Czechia	2.193	2.340
Romania	1.856	1.860
Austria	1.269	1.433
Bulgaria	1.403	1.404
Portugal	0.993	1.020
Denmark	0.751	0.953
Hungary	0.349	0.765
Slovakia	0.506	0.509
Sweden	0.230	0.400
Poland	0.165	0.300
Slovenia	0.284	0.294
Malta	0.155	0.183
Cyprus	0.172	0.177
Finland	0.044	0.162
Luxembourg	0.108	0.110
Croatia	0.079	0.080
Lithuania	0.068	0.080
Ireland	0.011	0.020
Latvia	0.000	0.001
Estonia	0.000	0.000
Total EU 28	113.510	122.316

Source: EurObserv'ER 2019

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huge volumes of residential systems in the rental and new build sector. A recent Energieonderzoek Centrum Nederland research institute report suggests that the country's installed capacity could rise to 6 GW in 2020 and to 20 GW by 2035

Large-scale competitive solar projects in France

Despite a slight drop in its connection volume, France kept its position in the European rankings. Preliminary data released by the French Ministry of Ecological and Inclusive Transition's Monitoring and Statistics Directorate (SDES), shows that France connected 862.4 MW of capacity to the grid (908.4 MW in 2017). If we subtract decommissioned installations (6.9 MW), the country's peak capacity (i.e. the maximum capacity that can be delivered to the grid) stands at 9 466 MW. However, the SDES stipulates that this data is provisional and does not include the off-grid capacity that Enedis puts at 30 MW in 2018 (17 MW in 2017). The SDES points out that the installed base peak capacity assessment is a few hundred MW higher than the capacity declared in the connection contracts (put at 8 917 MW at the end of 2018). This difference may stem from re-appraisal of the maximum capacity delivered to the grid between the contract signing and the declaration made for purchase obligation purposes and by minimising the declared capacity at the connection stage to reduce connection costs.

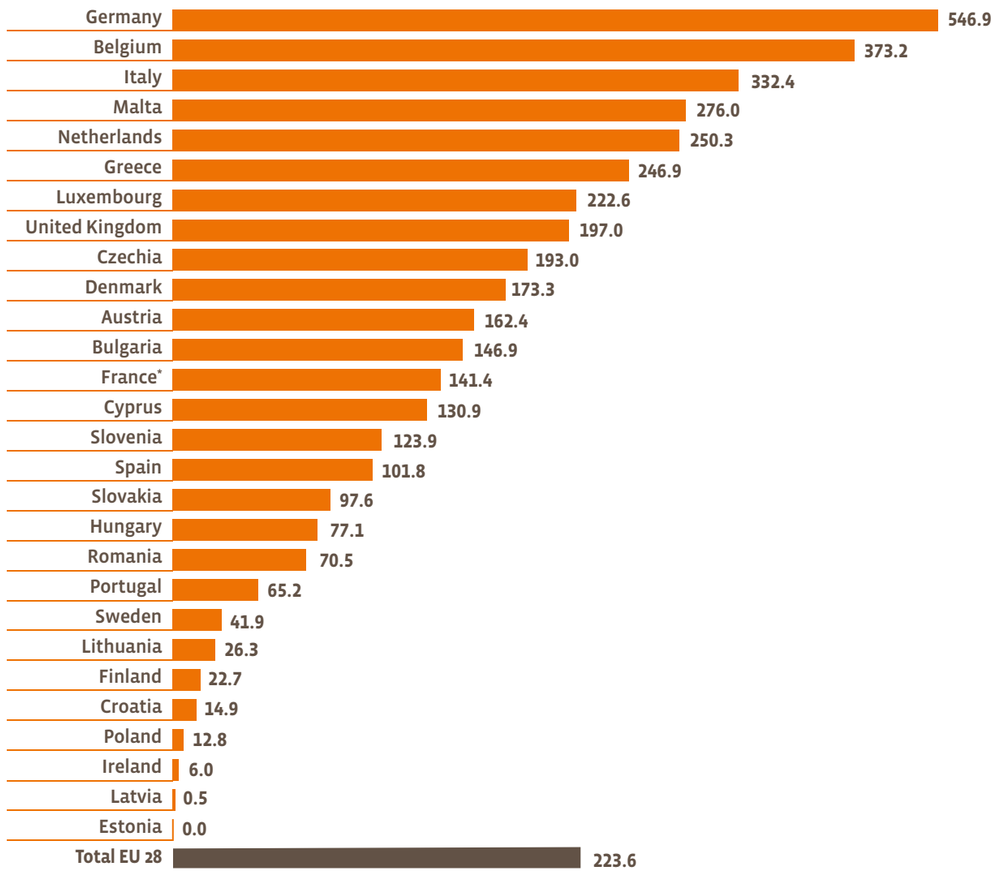
In France, the results of the 5th round of "Ground-based plants with capacities ranging from 500 kWp to 30 MWp" tenders have been released. On 28 February 2019, 118 successful bidders were named for the total volume allocated of 855 MWp (the demand capacity was 850 MW). The mean bid price for all projects is € 62.7 per MWh, which is a slender 3% increase on the previous bidding round. The mean bid prices for each rating class are as follows:

- € 56.8 per MWh for high-capacity installations of 5–30 MWp, for 557 MW of combined capacity (prices in the € 43–65 per MWh range).
- € 63.8 per MWh for installations with capacities ranging from 500 kWp to 5 MWp, for 233 MW of combined capacity (prices in the € 47–104 per MWh range).
- € 87.5 per MWh for carport shade installations for 65 MW of combined capacity (prices in the € 61–130 per MWh range).

In February 2019, the French Energy Regulatory Commission (CRE) published its "Costs and profitability of large solar power plants in mainland France" report, which set the French specialist energy press alight. The document, which details the current installation costs of medium- and high-capacity photovoltaic power plants (100 kWp to 30 MWp), clearly implies that the sector's costs are plunging. Investment costs have dropped by an average 32% over the past three years. The least expensive large-scale ground-based projects now approach € 600 per kWp. Average installation type – and size – dependent production costs calculated with reference to the recent "CRE4" tendering rounds currently range from € 62–99 per MWh. The production costs of 30% of the most competitive large-scale ground-based projects, whose capacity is limited to 30 MWp and until recently to 17 MW, are around € 48 per MWh. These figures are similar to the full production costs observed elsewhere, primarily in Germany. The CRE holds that for a considerable fraction of large-scale projects, the production costs are similar if not lower than the recent years' market prices. The situation is likely to pave the way for these projects to develop without public aid – a trend witnessed in other European countries.

Graph. n° 1

Photovoltaic capacity per inhabitant (W/inhab.) for each EU country in 2018



** French overseas departments included.* ***Source: EurObserv'ER 2019.***

KEEN COMPETITION STILL CHALLENGES THE SECTOR

GLOBAL TECHNOLOGICAL CHANGE FROM THE WAFER TO THE MODULE

Since 2012–2013, the world's photovoltaic market has suffered from manufacturing overcapacity. Global supply has exceeded demand. The root cause is the proliferation of Chinese companies, some of which emerged very rapidly on the market with gigawatts of annual cell and module manufacturing capacities **(see table 5).** This trend slewed the balance of the photovoltaic market's upstream supply side, from silicon production through to module manufacturing.

Chinese companies were again behind the global market change from 2016–2019, but this time the change was more qualitative than quantitative in nature, because of the leap in the average efficiency of cells and modules. It started when monocrystalline wafer supplies increased at the expense of polycrystalline wafers, and in 2018, monocrystalline technology overtook polycrystalline for the first time. The move was prompted by the company LONGi, the biggest wafer manufacturer. While the company "only" delivered 3 GW of monocrystalline wafers per annum in 2014, it rapidly increased to 15 GW in 2017 and 28 GW in 2018. Its plans have not stopped there, because it now wants to achieve 45 GW of manufacturing capacity in 2020. As the company is fully integrated, it also manufactures its own modules and had 8 GW of capacity in 2018. Furthermore, as construction work has started on a 5 GW-capacity factory, LONGi should be the top global module manufacturer with 13 GW of capacity by the end of 2019.

Tabl. n° 5

Main photovoltaic module manufacturers in 2018

Company	Country	Shipment (MW)
Jinko Solar	China	11 380
JA Solar	China	8 800*
Trina Solar	China	8 100*
LONGi Solar	China	7 200*
Canadian Solar	China	6600
Hanwha Q-CELLS	Korea	5 600*
Risen Energy	China	4 800*
GCL-SI	China	4 100*
Talesun	China	2 900*
First Solar	USA	2706

Estimates from GlobalData.* ***Sources: Annual reports, GLobalData.*

Over the past two years, most of the Chinese photovoltaic players have delisted from the American stock exchange. As they are no longer subject to the same communication obligations, information about them has become much scarcer. This primarily applies to their annual delivery figures, total manufacturing capacity and turnover.

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Global technology change does not only apply to the shift to monocrystalline wafers. The market for cells is also moving towards high-efficiency product massification and standardisation, primarily towards PERC (Passivated Emitter Rear Contact) technology, which can be defined as cell architecture that improves light capture near the rear surface to maximize electron production. In 2014, global PERC monocrystalline cell capacity was no more than 1 GW. In 2019, it should exceed 60 GW, which is more than half of global photovoltaic cell manufacturing capacity. The company Jinko Solar announced, that by the end of 2018 it would have 9.7 GW of wafer manufacturing capacity including 5.7 GW for monocrystalline and 7 GW for cells including 4.2 GW of PERC cells. There was a flurry of new efficiency record announcements in 2018; for example, in January 2019, LONGi proclaimed it had developed a cell whose efficiency is slated to be 24.06%.

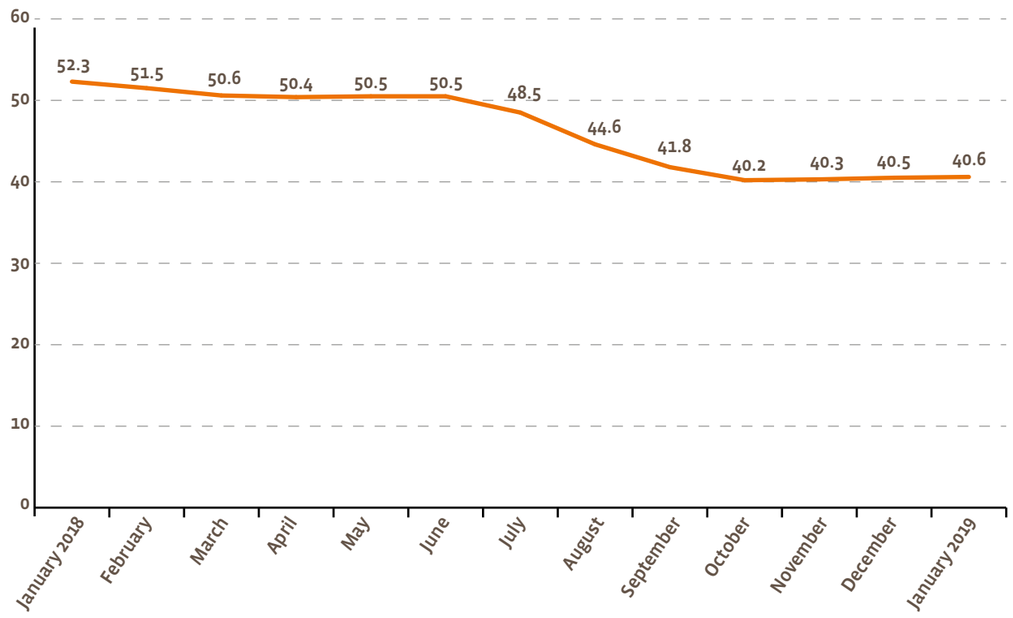
As PERC technology becomes the norm, which other technologies will go further still? The first priority will be to improve PERC cells, and to do so, the industry is exploring TOPCon technology (which involves adding an oxide layer). This will take today's cells sold with 22% efficiency to 23% in two to three years' time. Another technology, heterojunction, blends crystalline silicon with amorphous silicon, that can reach higher efficiency thanks to the perovskite.

In Europe, the Swiss Meyer Burger group's strategy is also symptomatic of photovoltaic technology progress. The company, which specializes in building photovoltaic cell manufacturing machines, supplies equipment for manufacturing PERC cells that could in time be supplemented by machines that make TOPCon cells. In 2018, the group, which has taken orders for this type of equipment equivalent to 8 GW of manufacturing capacity, admitted that it is facing competition from new Chinese players.

In 2018, the Norwegian group REC revealed it was investing 150 million dollars to manufacture heterojunction cells using Meyer Burger systems. In addition, at the very end of 2018, the Swiss group stated that it had taken an order for the equivalent of 600 MW of heterojunction cells from a "non-Chinese" group. Against this backdrop, Meyer Burger declared a strategic redeployment plan in October 2018. It will relocate part of its business dedicated to manufacturing equipment for standard cells to China, as well as some of its R&D activities. In contrast, its European activities will concentrate on heterojunction and to accelerate progress in this area, the group is buying up 18.8% of the English company Oxford PV, that specializes in perovskite cells.

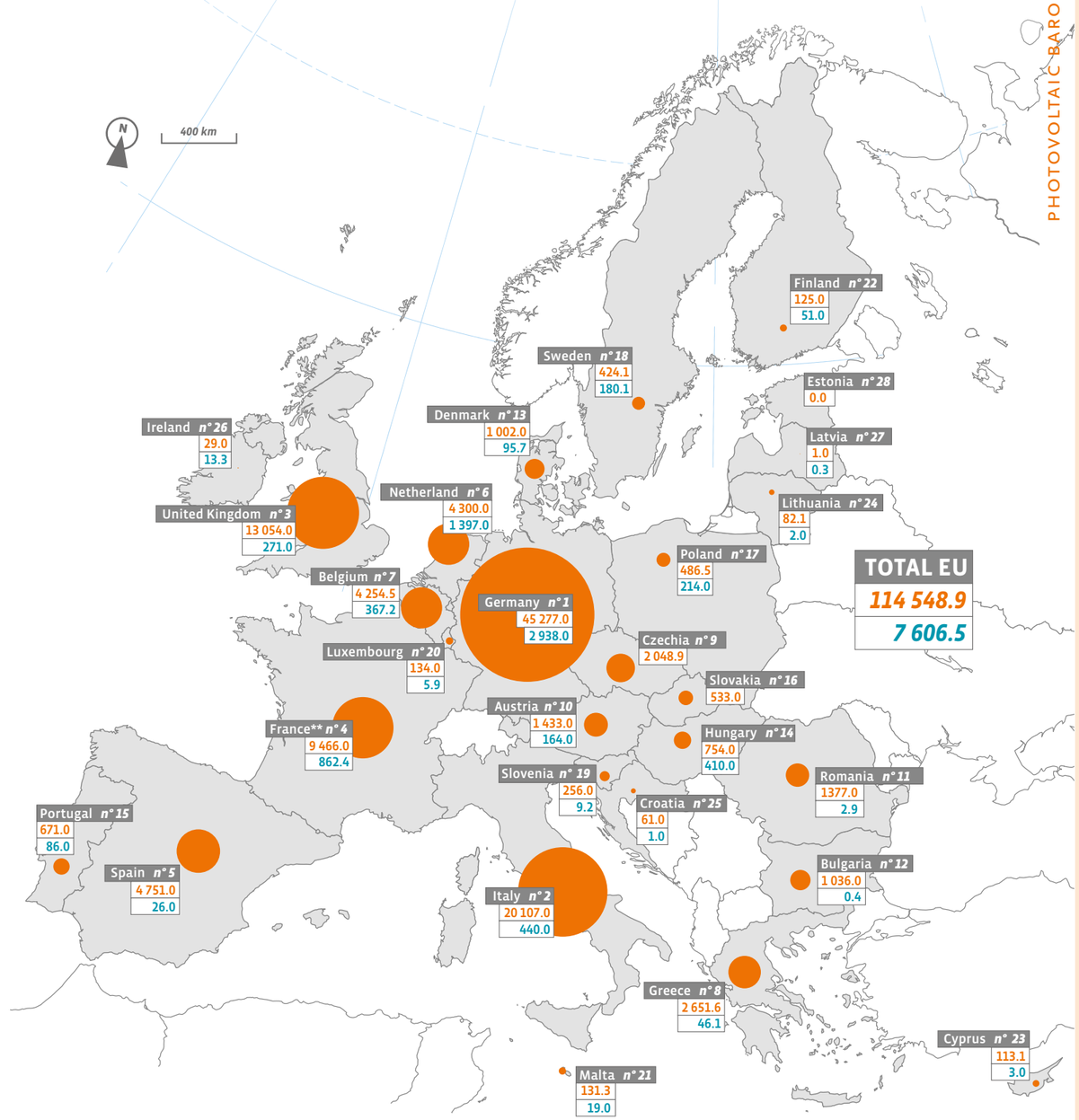
Graph. n° 2

Average spot price of a monocrystalline module on the German market (euro cents per W)



Source : Photon International.

Photovoltaic capacity connected in the European Union in 2018 (MW)*



Key

114 548.9 Connected and cumulated photovoltaic capacity in the European Union countries at the end of 2018* (MW)

7 606.5 Photovoltaic capacity installed and connected in the European Union countries during the year 2018* (MW)

Estimate. **Overseas departments included for France.* ***Source: EurObserv'ER 2019.*

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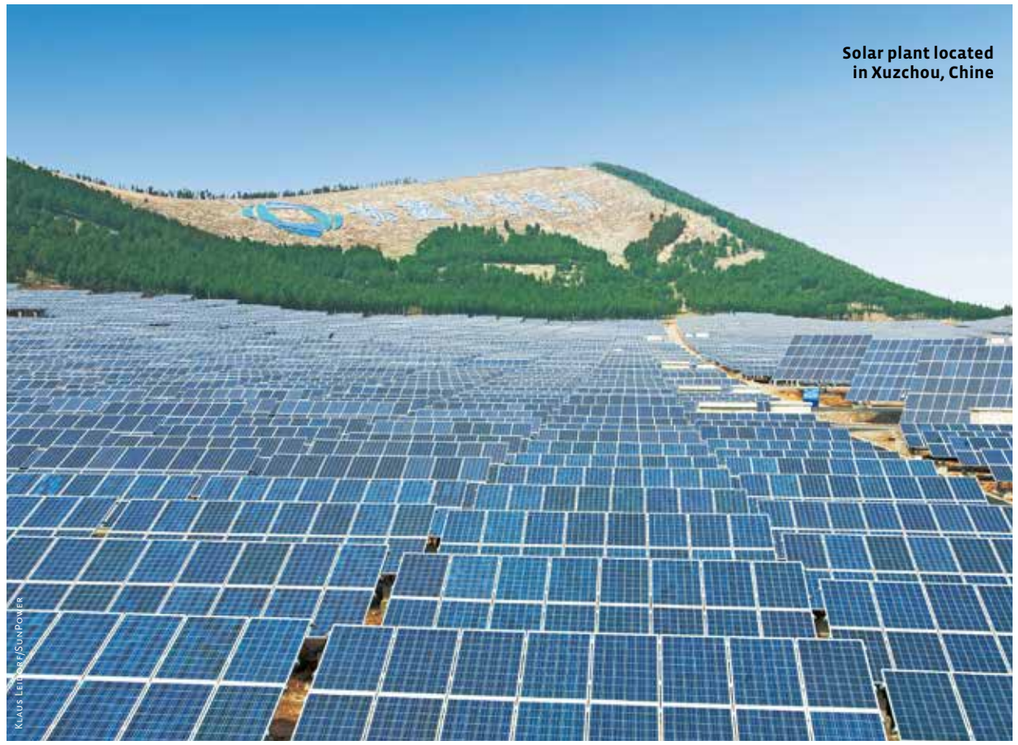


Solar plant located in Xuzchou, Chine

KLAUS LEITNER/SUNPOWER

THE END OF SANCTIONS

At the beginning of the decade, the global market was rocked by the massive supply of products primarily made in China. The European Union introduced customs duties at its borders in 2013. The move aimed to protect its manufacturers from under-priced products that threatened their survival. The module manufacturer, SolarWorld, took up the stand as the main advocate for maintaining these customs barriers. However, the barriers were unable to keep the company going, and SolarWorld filed its first insolvency proceedings in May 2017. Then in March 2018, despite being "saved" by Qatar Solar Technologies, the company went bankrupt again. SolarWorld blamed the scheduled end of the customs tariffs for its demise.

The European Union did indeed lift its customs barriers at the very start of September 2018. This policy hit photovoltaic prices in 2018, as shown by **graph 2.** In the German market, the average price of a monocrystalline module dropped from 48.5 euro cents per watt at the end of July to 41.8 euro cents in September 2018. For all technologies taken together, the price fall was sharper for modules made in Europe, which dropped by 6.1% between August and September 2018, stabilizing at 40.4 euro cents per watt. At the same date, solar panels from China were selling at 35.6 euro cents per watt.

DIGITALIZATION AND DECENTRALIZATION OF PHOTOVOLTAIC ENERGY

Over and above the equipment manufacturing aspect, photovoltaic energy also exists in an increasingly digital and "intelligent" environment. Downstream competition is also stiff, and companies must make constant progress to meet market expectations. Accordingly, the German inverter manufacturing specialist SMA rolled out a new restructuring plan for 2019. One of the key points is the group's withdrawal from the Chinese market, to reduce its annual costs of 40 million euros. The company reckons that inverter market sales will remain stable over the next few years (they amounted to 4.3 billion euros for the group in 2018). This contrasts with digital services for the energy market, i.e., the use of multiple data to improve consumer service, which should more than treble by 2021, rising from 400 million to 1.8 billion euros for the group. The segment of the company dedicated to electricity storage should also grow by 60%, from 500 to 800 million euros in 2021.

The storage and battery markets are also growing very fast in parallel with renewable energies and photovoltaic. In a report published in the summer of 2018, entitled "Global Market Outlook for Solar Power", the SolarPower association explains that the coupling of photovoltaic with storage forms "a new flexibility tool", that enables photovoltaic power to be fully deployed. Incidentally, the topic of batteries has led to the relaunch of the idea of a European gigafactory, dedicated to batteries. This point is particularly poignant for Germany, as it is linked to the automotive sector, one of the country's main economic drivers. In 2017, the company TerraE was set up to construct Germany's first lithium-ion cell factory. It was subsequently bought out in November 2018 by BMZ to kick off the project's operational phase. Thus, Germany should have a plant with 4 GWh of battery manufacturing capacity in 2020. In the long term, it could be extended to produce 8 GWh. Incidentally, in November 2018 Peter Altmaier, the Federal Minister for Economic Affairs and Energy, announced the release of one billion euros to subsidise the industrial development of batteries. France has also committed to this approach and the two countries are trying to work together to identify consortia capable of turning this political ambition into industrial reality.

PHOTOVOLTAIC ENJOYS A REVIVAL IN THE EUROPEAN UNION

As the European 2020 deadlines approach, many countries need to accelerate the implementation of their solar projects to fulfil their renewable energy obligations, so the European Union should experience strong demand in the next two years. According to EurObserv'ER, which has upscaled its forecasts from those of last year's barometer, this growth should suffice to reach at least 135 GW by 2020 (graph 3). Also, it is becoming increasingly frequent to see lower prices guaranteed by tenders than the average electricity prices applied in the market. This fully justifies the European Commission's determination to implement its market mechanism policy. New subsidy-free business models are emerging for very large-scale power plants alongside tenders, such as power purchase agreements between producers and major consumers, with for example projects for several GW already announced in Spain.

Aurélie Beauvais, SolarPower Europe's Policy Director, feels that the European Commission has completed its share of the work by removing the commercial barriers applied to Chinese modules and ensuring that a very positive development framework is in place for the solar sector through the implementation of the "Clean Energy for All Europeans" package. An integral part of this package, the Renewable Energy Directive dated 11 December 2018 has thus laid foundations that are highly conducive to solar self-consumption. The directive instructs the Member States to set up a regulatory framework to enable all individuals to produce, consume their own output, store and sell electricity, without having to bear disproportionate charges. The Member States are under obligation to adopt the self-consumption measures into their national legislation before 30 June 2021. Distributed solar, be it backed by a policy that encourages individual and collective self-consumption or totally intended for resale, will go a long way to promoting solar power development. The package also includes the regulation and directive relating to the electricity market. As for the latter, an important milestone was passed on 26 March 2019, when the European Parliament adopted new rules on the organization of the EU electricity market. They have been devised to give consumers the means to play an active role in energy transition and make the very most of a less centralized, more digitalized and more sustainable energy system. Consumers will be able to become fully-fledged market players using smart meters, price comparison tools, dynamic pricing and citizens' energy cooperatives. One of the aims is to meet renewable energy-related requirements and attract investments in sectors such as energy storage. The new Electricity Market Regulation and Directive still awaits formal approval by the European Council.

This new framework can now be politically expressed through the very ambitious 2030 National Energy and Climate Plan targets and is the pledge that the solar electricity share will increase significantly over the next decade. For instance, Spain, Italy and Portugal have restated their high ambitions for renewable electricity for the next decade. Portugal, for its part, released a new energy strategy at the end of 2018 that aims to produce 80% of renewably-sourced electricity by 2030. To achieve this, in February 2019 the Portuguese government approved a major programme through to 2027 worth 535 million euros to strengthen its grid so that it can integrate large volumes of renewable energy. The plan includes the construction of two major transmission lines to transfer the power generated by future solar farms in the south of the country to consumption areas further north. Last December, the Italian Economic Development Ministry also published its new 2030 National Integrated Plan for Climate and Energy with a 2030 output target for photovoltaic of 50 GW. The Spanish government upscaled its ambitions in February 2019 by approving the "three essential pillars" of its climate policy (the preliminary draft of the Climate Change Law, the Integrated National Energy and

Tabl. n° 6

Main European solar photovoltaic developers in 2018

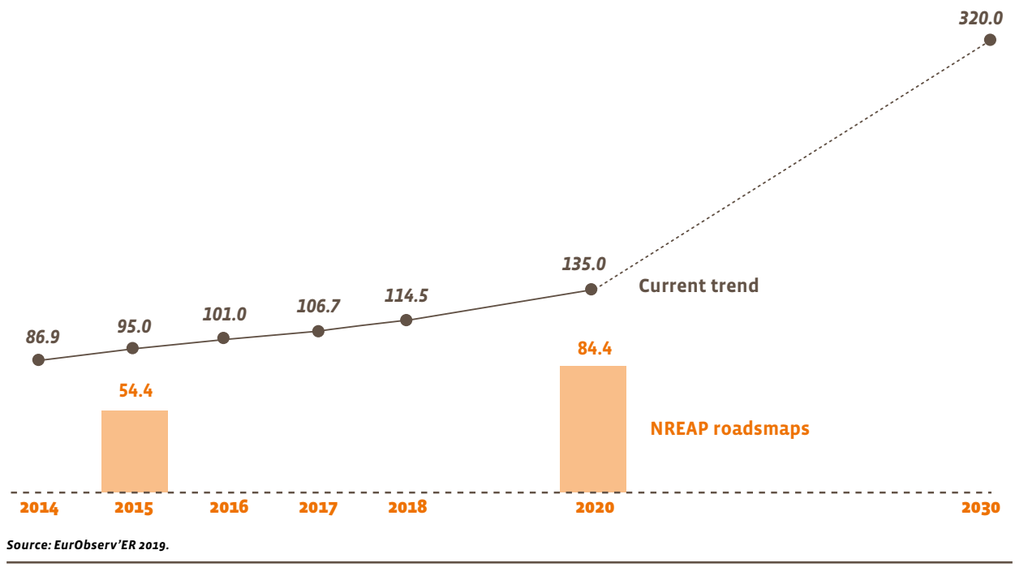
Company	Country	Installed photovoltaic capacity (MW)
Enerparc	Germany	2 000
Lightsource BP	United-Kingdom	2 000
EDF Renouvelables	France	2 402
Juwi AG	Germany	2 500
Belectric	Germany	2 240
Voltalia	Portugal	1 800
Enel Green Power	Italy	1 553
Scatec Solar	Norway	> 1000
ENGIE Green	France	935 (France)

Source: EurObserv'ER

Security test on photovoltaic modules

Graph. n° 3

Comparison of the current trend of photovoltaic capacity installed against the NREAP (National Renewable Energy Action Plans) roadmap (in GW)



Source: EurObserv'ER 2019.

Climate Plan 2021-2030 and its Fair Transition Strategy). The country now plans to increase the renewably-sourced share of its electricity output to 74% by 2030 to meet 41% of its energy demand. More than 60 additional GW of solar electricity will be needed to meet this target.

Clearly, the sector's ambitions are commensurate with the challenges. At the 2nd Clean Energy Industrial Forum organized by the European Commission held in Brussels in March 2019, SolarPower Europe presented a new roadmap describing an ambitious industrial strategy for solar energy in Europe. It forecasts that at the end of 2030, there will be 300 000 solar energy related jobs, compared to 81 000 full-time equivalent jobs (FTE) in 2016, that at least 20% of Europe's electricity demand will be supplied by solar energy and that a minimum of 30 million solar roofs installed in Europe. All of this constitutes a good base for achieving the European Commission's planned carbon-neutral target by 2050.

Over the past two years, most of the Chinese photovoltaic players have delisted from the American stock exchange. As they are no longer subject to the same communication obligations, information about them has become much scarcer. This primarily applies to their annual delivery figures, total manufacturing capacity and turnover. □

AGEE-Stat (Germany), SDES (France), BEIS (United Kingdom), Statistics Netherlands, GSE (Italy), APERE (Belgium), Statistics Austria, IDAE (Spain), PV Polska (Poland), Swedish Energy Agency, DGGE (Portugal), ENS (Denmark), Finnish Energy, Cyprus Energy, CRES (Greece), Ministry of Industry and Trade (Czech Republic), Observ'ER, IRENA, IEA PVPS.

The next barometer will cover solar thermal.

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