

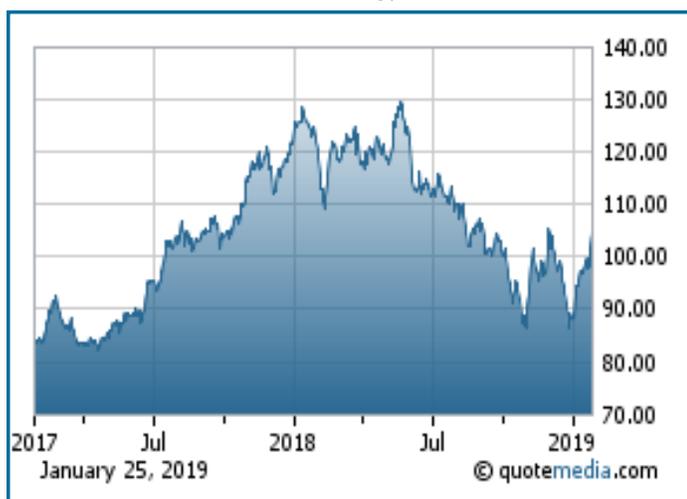
## SOLAR SECTOR UPDATE

The MAC Global Solar Energy Stock Index (SUNIDX) is licensed as the tracking index for the Invesco Solar ETF\* (NYSE ARCA: TAN)

Note: Index performance does not reflect transaction costs, fees or expenses of TAN.

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MAC Global Solar Energy Index (SUNIDX)



### SOLAR INDEX PERFORMANCE

The MAC Solar Energy Stock Index, the tracking index for the Invesco Solar ETF (NYSE ARCA: TAN), rebounded sharply higher in January from the 1-3/4 year low posted in October 2018. The index is currently up +18% on the year, reversing part of the -27% decline seen in 2018. The index in 2017 showed a strong gain of +52%.

Bullish factors for solar stocks include (1) the improved global solar demand picture that has resulted from the sharp drop in solar module prices in 2018 and the fact that solar has now reached grid parity in many places, (2) the stabilization of solar cell and module prices in late 2018 that helped the profitability of solar manufacturers, (3) expectations for strong solar growth in Europe in 2019 as unsubsidized solar grows due to lower solar pricing and the end of Europe's minimum import price (MIP) scheme, (4) broadening solar growth from India, Turkey, Latin America, Middle East, and Southeast Asia (see page 5 for the world solar growth outlook), (5) strong demand for renewable energy in general as countries seek to meet their carbon-reduction targets under the Paris COP21 global climate agreement, and (6) the low valuation level of the solar sector.

Bearish factors for solar stocks include (1) the tail-end impact of China's reduced subsidy support for solar that was announced in May 2018, which caused a big solar module inventory overhang and sharply lower solar module pricing during mid-2018, (2) the continued negative effect on U.S. solar from the Section 201 tariff of 30% on imported cells and modules that took effect in February 2018, and (3) the obstacle to India's solar growth from the government's safeguard tariff on solar modules.

Solar stocks continue to trade at low valuation levels compared with the broad market. The forecasted 2019 P/E of 14.6 for the companies in the MAC Solar Index is below the comparable figure of 15.8 for the S&P 500 index. The price-to-book ratio of 1.11 for the companies in the MAC Solar Index is well below the 3.17 ratio for the S&P 500. The price-to-sales ratio of 0.86 for the MAC Solar Index is well below the 2.03 ratio for the S&P 500.

### Solar stocks recover in January with expectations for solid 2019 solar growth

Solar stocks in January recovered due to (1) the partial recovery of global stock markets in January after the downside correction seen during October-December, (2) the recovery of the global solar industry after the blow from China's subsidy cut in May 2018, and (3) expectations for solid global solar growth in 2019.

Solar stocks were hit hard in mid-2018 after the Chinese government in May 2018 announced a sharp cut in its subsidy support, which caused a big drop in Chinese solar demand and a big drop in global solar pricing. However, the drop in Chinese demand was less severe than initially expected and solar pricing stabilized in late 2018, which helped to stabilize the profitability of solar manufacturers. Meanwhile, the sharp drop in solar pricing in 2018 was a windfall for solar developers, who can now bring more projects to market since solar is now even more competitive against alternatives like wind and natural gas.

The sharp drop in solar pricing in 2018 has made large-scale solar very competitive and is drawing major purchasing interest from utilities and corporations. A big pipeline of global solar projects has built up over the past year, which supports expectations for a strong year for solar in 2019. In China, the new year has brought

the return of China's solar subsidy programs as well as a pilot program for unsubsidized solar projects. In the U.S., solar is expected to be strong over the next several years as developers seek to take advantage of the investment tax credit (ITC) before it steps down to 10% in 2022. In Europe, utility-scale project pipelines are filling up now that solar has become competitive on an unsubsidized basis.

## Solar's electricity cost falls 12% and becomes even more competitive vs fossil fuels and nuclear

The levelized cost of electricity (LCOE) for newly-built utility-scale solar PV plants in late 2018 fell by -13% yr/yr to a midpoint of \$43 per MWh (\$40-46 range) for crystalline PV on an unsubsidized basis, according to Lazard in the latest annual edition of its comprehensive "Levelized Cost of Energy Analysis-Version 12.0" released in November 2018. The LCOE for thin-film solar fell by a similar -12% yr/yr to a lower mid-point price of \$40 per MWh (\$36-44 range).

While the cost of residential and corporate solar PV systems remains substantially higher than the cost of utility-scale solar, it also fell from year-earlier levels. The Lazard report found that the unsubsidized mid-point LCOEs are as follows: Community Solar -4% yr/yr to \$109/MWh (\$73-145 range), Roof-Top Commercial and Industrial -10% yr/yr to \$125.5/MWh (\$81-170), and Rooftop Residential -16% yr/yr to \$213.5/MWh (\$160-267).

Lazard's latest LCOE report shows that solar PV now easily beats the cost of newly-built coal plants (\$60-143/MWh), nuclear plants (\$112-189/MWh), and gas-peaking plants (\$152-206/MWh). The Lazard data shows that in most areas it is no longer economical

for a utility to build any new coal or nuclear plants.

Regarding the natural gas comparison, the crystalline solar PV cost range of \$40-46/MWh is now at the lower end of the range of \$41-74 for gas combined cycle plants, illustrating how solar either beats or at least matches natural gas, depending on the parameters of a specific project. The \$43/MWh mid-point of solar crystalline PV is actually -25% below the mid-point of \$57.5/MWh for natural gas for an average project.

While solar clearly wins against coal and nuclear for newly-built plants, the fact remains that existing coal and nuclear plants are still relatively cheap to operate. Lazard estimates the average marginal cost for running a nuclear plant is only \$28/MWh for nuclear and \$36/MWh for coal.

That comparison shows that solar and wind are not yet cheap enough that utilities have an economic incentive to mothball all their existing nuclear and coal plants and build new solar, wind and gas plants. However, as coal and nuclear plants reach the end of their useful life, utilities will clearly decide to switch to building new gas, solar and wind plants based on economics, with gas being their preference for baseload until storage starts to play a bigger role.

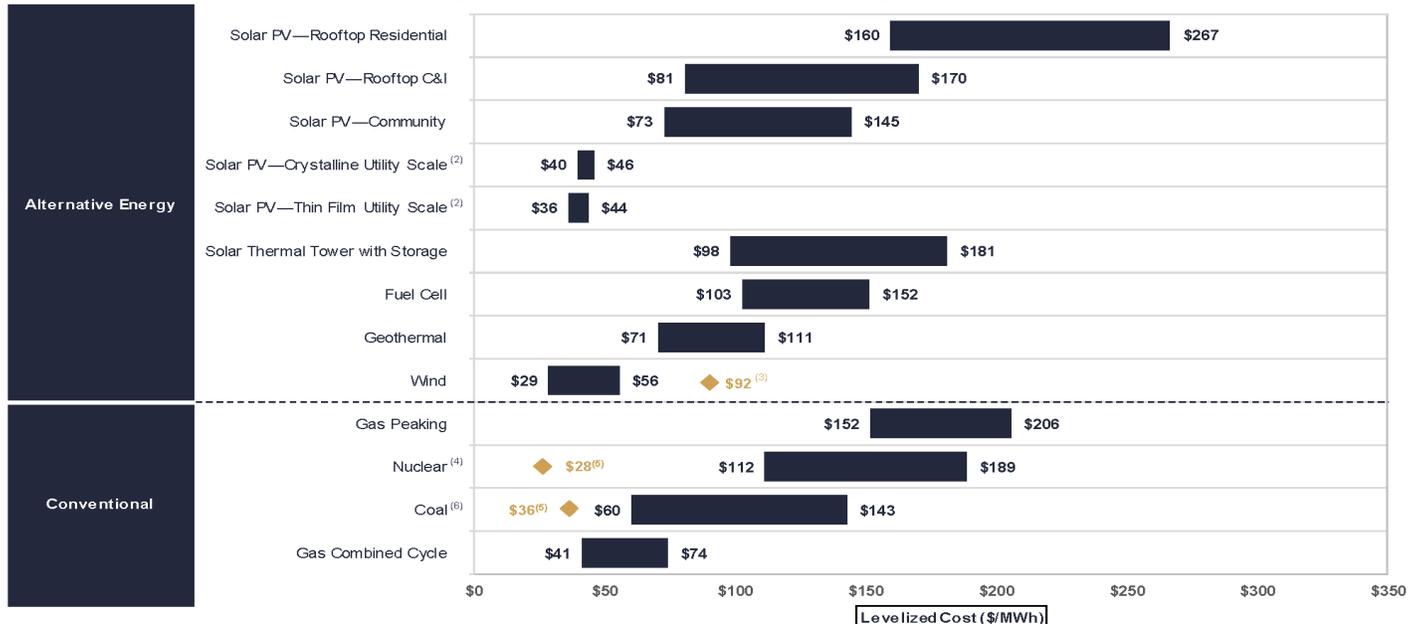
The average age of power plants in the U.S. is 39 years for coal plants and 37 years for nuclear plants, illustrating that utilities are facing pressure to build new electricity plants as old coal and nuclear plants reach the end of their useful life and must be retired. In addition, increased pollution and carbon constraints mean that the marginal cost of operating coal plants will be headed higher over the long run, thus encouraging utilities to phase out their aging coal plants sooner rather than later.

LAZARD'S LEVELIZED COST OF ENERGY ANALYSIS—VERSION 12.0

## LAZARD

### Levelized Cost of Energy Comparison—Unsubsidized Analysis

Certain Alternative Energy generation technologies are cost-competitive with conventional generation technologies under certain circumstances<sup>(1)</sup>



## NextEra Energy is going big on Florida solar

Utility-giant NextEra Energy Inc. is planning \$10 billion worth of utility-scale solar PV farms in Florida. The program would be the world's largest-ever solar build-out by a regulated utility. The plan involves building about 130 solar farms through 2030 with a total of 30 million solar modules generating 10 GW of electricity.

The utility is asking regulators to approve the plan based on its estimate that the solar plants will substantially reduce electricity costs for Florida's electricity users. The utility says that each of the 130 solar farms could save electricity rate-payers some \$40 million in fuel costs over its life.

## Solar beats wind in head-to-head auctions in Europe

Solar has consistently beat wind on cost in recent head-to-head contests in European power auctions. In Germany, for example, solar parks took all of the 201 MW of renewable power tendered in October. The only wind proposal that was submitted in that German tender was dropped because of its high price. The average winning solar bid was an impressively low 52.7 euros (\$60.1) per MWh.

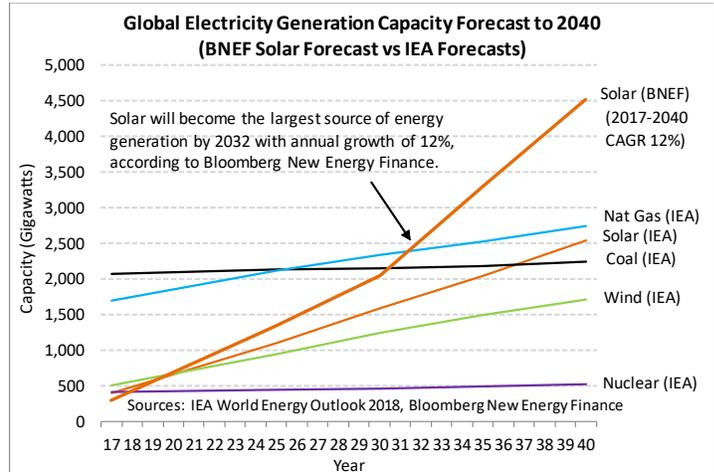
In France, solar was awarded all of the 200 MW of capacity in a renewable power auction that was held in November. A total of 16 solar projects were chosen. No wind projects were chosen because of higher wind pricing. The average price of the accepted solar projects in the auction was 54.9 euros (\$62.6) per MWh.

Separately, Germany in 2018 received more of its electricity from renewables than it did from coal for the first time ever. Renewables (wind, solar, hydro and biomass) generated just over 40% of Germany's electricity in 2018, beating coal's 39% share, according to the Fraunhofer Institute. Solar's electricity-generation share grew by 20% in 2018. Coal lost ground as old plants were mothballed. Germany is working on a plan to eventually phase out its nuclear plants.

## U.S. National Climate Assessment sees grim future

The U.S. "Fourth National Climate Assessment" offered a grim warning for the U.S. if action is not taken on global warming. The report found that global warming is already negatively affecting the U.S. with a 1.8 degree Fahrenheit rise in temperatures in the last 100 years, a 9-inch rise in ocean levels on the coasts, and far worse heat waves than have been experienced as recently as 50 years ago. The report said that damage from climate change is "intensifying across the country."

The report warns that millions of people may have to be relocated away from the coasts. The report says, "The potential need for millions of people and billions of dollars of coastal infrastructure to be relocated in the future creates challenging legal, financial, and equity issues that have not yet been addressed."



The report estimates the dollar costs related to global warming. The report says that in the worst-case climate-change scenario, labor-related losses as a result of extreme heat could rise to \$155 billion annually by 2090, deaths from temperature extremes could represent an economic toll of \$141 billion, and coastal property damage could total \$118 billion annually.

The report notes that other effects of climate change include reduced snow and water supplies in the western U.S. mountain ranges, bleached coral reefs, increased wildfire damage, and disruption to Alaska's ecosystems such as ice-clogged coastlines and thawing permafrost.

The report is the U.S. government's fourth comprehensive assessment of U.S. climate-change impact issued since 2000. The report is mandated by Congress and is issued every four years. The November report was compiled by 13 federal departments and agencies and by the U.S. Global Change Research program. The report was compiled independently of the White House and a NOAA spokeswoman said the report was not "altered or revised in any way because of political considerations."

## IEA forecasts that solar will become second largest electricity source by late-2030's

The International Energy Agency (IEA) in its latest annual "World Energy Outlook" published in November predicted that solar by the late-2030s will become the world's second largest electricity source behind natural gas, as seen in the above graph. The IEA predicted annual growth for solar of +8% through 2040, reaching 2,500 GW in 2040 from about 400 GW in 2017.

The IEA in the past has woefully under-estimated solar's actual growth rates. Indeed, the IEA in its latest report was forced to raise its solar forecasts by 20% from the year-earlier report. Even after that hike, the IEA is still lagging far behind solar forecasts by Bloomberg New Energy Finance (BNEF). BNEF is forecasting that solar will beat even natural gas to become the largest source of electricity by 2032 and that solar will show an annual growth rate of +12% through 2040.

The IEA report also warned that "unprecedented" investment action is needed to avert a climate crisis. The IEA says that global CO2 emissions rose by +1.6% in 2017 and will continue to rise slowly through 2040.

## Solar-plus-storage takes off in Hawaii

The Hawaiian utility company Hawaiian Electric in early January sent seven solar-plus-storage contracts to state regulators for approval with a record-low average price of 9 cents per kWh (\$90/MWh). Two of the projects came in at 8 cents/kWh. The combined size of the seven solar-plus-storage systems is 262 MW of solar and 1.048 GWh of storage. The projects will be built on three different Hawaiian islands.

The average price of 9 cents/kWh for the Hawaiian solar-plus-storage projects is well below Hawaii's cost of about 15 cents per kWh for generating electricity by burning oil. Hawaii is heavily dependent on burning oil for its electricity since oil accounts for 74% of Hawaii's total electricity generation, according to the U.S. Energy Information Administration (EIA). Hawaii has adopted a goal of going 100% renewable by 2045. Hawaii currently generates about 14% of its power from renewable sources with the rest being oil (74%) and coal (12%), according to the EIA.

Meanwhile, a solar-plus-storage project on the island of Kauai that is owned and operated by AES Corp is ready to go on line with power-purchase-agreement (PPA) pricing of 11 cents/kWh. The size of the plant is 28 MW of solar PV and 100 MWh of lithium-ion battery capacity.

The 8-11 cent/kWh pricing of these various Hawaiian solar-plus-storage projects is at or below Lazard's LCOE estimate for a solar-plus-lithium-battery system of 10.8-14.0 cents/kWh in its November "Levelized Cost of Storage Analysis V4.0" report. The low prices of the recent solar-plus-storage projects in Hawaii are particularly impressive given the relatively high construction costs on islands in Hawaii.

On the U.S. mainland, solar-plus-storage systems are coming in at significantly lower prices. A solicitation last year by Xcel Energy for a solar-plus-storage plant in Colorado saw a median bid of an extremely low 3.6 cents/kWh for delivery in 2023. That was lower than a deal signed by Tucson Electric in May 2017 of 4.5 cents/kWh.

Solar-plus-storage will become even cheaper in coming years. Lithium-battery prices have already plunged by 85% since 2010 and will fall by another 52% by 2030, according to BNEF.

## SOLAR PV GROWTH OUTLOOK

Solar is expected to regain strength in 2019 after the obstacles seen in 2018. Bloomberg New Energy Finance (BNEF) is forecasting that solar installs in 2019 will grow by +15% to 125 GW from their estimate of 109 GW in 2018. Meanwhile, IHS Markit is forecasting that world solar installs in 2019 will grow by +18% to a similar level of 123 GW from their estimate of 104 GW in 2018. Solar growth charts can be seen on page 10.

Solar growth in 2018 was hindered by a pull-back in Chinese installs and by an overall global retrenchment after two very strong solar growth years in 2016 (+34%) and 2017 (+31%). In 2018, world solar growth rose by +10% to 109 GW from 99 GW in 2017, according to BNEF. Solar growth over the past five years (2013-18) has shown a strong compounded annual growth rate of +21%.

Solar looks set to resume its strong growth in coming years as very low solar costs boost long-term demand for solar. In addition, past boom/bust solar cycles caused by ill-advised government subsidy policies should soon become a thing of the past as unsubsidized solar becomes prevalent. BNEF is forecasting +12% annual solar growth through 2040, with solar capacity up 11-fold to 4,500 GW by 2040 from 420 GW in 2017.

Solar will account for some 35% of all electricity capacity additions and a massive \$3.4 trillion of total solar spending through 2040, according to BNEF. BNEF forecasts that solar PV will account for 25% of world electricity capacity by 2050, up from the current level of about 2%.

Demand for solar should surge in coming years as solar costs continue to fall and as solar becomes even more competitive against fossil fuels and nuclear. Solar's levelized cost has already plunged by an overall -83% since 2010 and by an average -16% per year over the last five years, according to Lazard. Lazard estimates that crystalline solar's current levelized cost of electricity (LCOE) midpoint of \$43/MWh beats natural gas at \$57/MWh, coal at \$101/MWh, and nuclear at \$150/MWh (Lazard LCOE 12.0, November 2018).

Looking ahead, BNEF expects a further -71% drop in the cost of solar PV plants by 2050, which would make solar the cheapest source of electricity by far.

### Optimism grows for Chinese solar in 2019 after the 2018 slowdown

China comes into 2019 on a more optimistic note as the government resumes its subsidies, continues its special solar programs, and starts a new pilot program for unsubsidized solar.

Chinese government officials are also expected to soon announce a higher 2020 solar target. Chinese officials at a symposium with industry members in November suggested that the 2020 solar target might be raised as high as 270 GW from the current level

of only 110 GW. China at the end of 2018 had installed solar capacity of about 178 GW, implying annual solar targets of around 45 GW for 2019 and 2020. Chinese solar installs in 2018 fell by -19% to 43 GW from 53 GW in 2017, according to BNEF.

The Chinese solar sector was hit hard in 2018 after the Chinese government on May 31, 2018, announced a halt to subsidies for utility-scale solar at 40 GW and roof-top distributed generation (DG) at 10 GW. The government also cut the electricity tariff for ordinary solar farms by -9% and cut the subsidy for DG projects by -14%.

The Chinese government's subsidy crackdown became known as the "China-531" order since it was announced on May 31, 2018. While the China-531 order capped utility and DG solar, it left in place the government's support for the "Top Runner" and "Poverty Alleviation" programs and residential solar. The government was forced into its China-531 action by the big backlog of unpaid subsidies that reached \$23 billion by the end of 2018. The government also needed to curtail solar overcapacity in some provinces.

The generous subsidies prior to the China-531 order caused Chinese solar installs in 2017 to balloon by +76% to 53 GW, which accounted for 54% of all world installs. The China-531 order caused Chinese solar installs to fall sharply in the second half of 2018, leading to a bulge in module inventories, a sharp drop in pricing for polysilicon and solar cells/modules, and a sharp drop in the stock prices of many solar manufacturers.

The China-531 announcement indicated that the Chinese government wants to encourage solar to move towards subsidy-free growth and an increased reliance on competitive auctions, a model that is finding success in many other countries.

Indeed, Chinese officials in early January announced that they will soon launch a series of subsidy-free solar and wind projects to pave the way for an eventual phase-out of subsidies. China's National Development and Reform Commission (NDRC) said that, "Some regions with good natural resources and firm demand have already achieved subsidy-free, or grid price parity, conditions." The NDRC noted that Chinese solar costs have plunged by -45% from 2012 through 2017. The goal of the pilot program will be to deliver solar at costs at, or below, the cost of coal-driven power plants.

China's Photovoltaic Industry Association called the Chinese government's new unsubsidized pilot program "good news" and noted that, "There will still be subsidized wind and solar projects, and the unsubsidized projects are only an addition." BNEF is forecasting that subsidy-free solar pilot program could add 10-15 GW of solar installs per year.

China's subsidy-free pilot projects will still offer two major support measures with a 20-year fixed on-grid electricity tariff at or below

## SOLAR PV GROWTH OUTLOOK (CONTINUED)

coal pricing and a guarantee of priority dispatch versus other types of electricity generation. The program will last at least until the end of 2020, which means that solar developers will likely scramble to get into the program in the event the benefits are later dropped of the 20-year fixed tariff and guaranteed dispatch.

The subsidy-free projects will not receive any subsidy from the national government, but they can still qualify for local subsidies that can last 3-5 years and they will also receive Renewable Energy Credits (RECs) for their electricity generation, which will boost their income since they can sell those RECs.

### U.S. solar growth expected to resume after recent volatility

U.S. solar growth is expected to resume in coming years due to (1) increased solar demand stemming from the sharp drop in solar costs, (2) the increased popularity of solar-plus-storage systems due to the sharp drop in battery costs, and (3) the desire by solar developers to take advantage of the U.S. solar investment tax credit (ITC) before it partially expires in 2022.

U.S. solar installs in 2019 will grow by +20% to 12.3 GW from 10.2 GW in 2018, according to BNEF. The expected 2019 growth rate of +20% would be a big improvement after the -9% decline seen in 2018 to 10.2 GW and the -20% decline seen in 2017 to 11.2 GW from the record high of 14.1 GW posted in 2016 (BNEF.).

U.S. solar installs in 2019 and 2020 are expected to be strong as solar project managers seek to take advantage of the solar investment tax credit (ITC) which is unchanged at 30% in 2019 but will step down to 26% in 2020 and 22% in 2021. In 2022, the ITC will expire entirely for direct-owned residential projects but will remain at 10% indefinitely for utility PV projects, non-residential, and third-party-owned residential solar projects. In order to qualify for the ITC, projects only need to commence construction by the end of the year in question, as opposed to the previous requirement where the project needed to be finished and grid-connected by year-end.

Yet U.S. solar growth over the next several years will still be hampered by the Section 201 tariff on imported solar cells and modules that was announced by the Trump administration in January 2018. That tariff is keeping U.S. solar module prices higher than they would otherwise be, thus hurting the economics of solar projects that are forced to use tariffed foreign-made modules.

The initial Section 201 import tariff of 30% in 2018 stepped down to 25% in 2019 and will fall farther to 20% in 2020, 15% in 2021, and zero in 2022 as it expires. The first 2.5 GW of solar imports are exempt from the tariff. Thin-film solar modules, such as those produced by First Solar, are exempt from the tariff even if

those modules are imported from overseas factories. The only significant solar-producing countries that are exempt from the tariff are India, Turkey, Brazil, and South Africa. However, imports from those exempted nations are capped each year at 300 MW each and at 900 MW as a group.

Despite the new tariff, U.S. utility solar procurement in 2018 surged because the announcement of the Section 201 tariff in January 2018 removed the uncertainty from the marketplace that hurt solar installs in late 2017 and early 2018. Wood Mackenzie reports that 11.2 GW of utility-solar projects were announced in the first 10 months of 2018, which means there is a very strong pipeline for finished projects in 2019 and 2020. Wood Mackenzie reports that the surge in utility-solar demand is due to a more-certain policy environment and also to the sharp drop in solar module costs that followed China's May 2018 subsidy cut.

Back in 2017, the threat of the Section 201 import tariff caused a sharp drop-off in solar installs as solar developers waited for the details of the tariff announcement, which finally came in January 2018. In addition to tariff uncertainty, the -20% yr/yr decline in 2017 solar installs was also due to a return to more normal growth levels after the growth spike seen in 2016. That 2016 growth spike of +92% to a record 14.1 GW was caused by a big spike in solar utility projects seeking to beat the scheduled expiration of the ITC at the end of 2016, although Congress in December 2015 ended up extending the ITC by 5 years.

In a positive development for U.S. solar growth, Deloitte in its recent 2019 Renewable Energy Industry Outlook report said that U.S. solar is now dominated by "voluntary demand" as opposed to demand driven by policy mandates. Deloitte estimates that voluntary procurement represented 52% of utility-scale solar in development and 73% of total projects announced in the first half of 2018. Deloitte also notes strong voluntary renewables demand from corporations, which purchased a record-breaking 4.96 GW of solar and wind capacity in the first ten months of 2018.

Solar in the first nine months of 2018 accounted for 30% of total U.S. new electricity generation installs, according to Wood Mackenzie. Solar's 30% share of new electricity was behind the 56% share of natural gas installs, but well head of wind at 13% and the negligible levels for other sources such as coal and nuclear.

On the tariff front, the U.S. solar sector is also dealing with potentially higher solar inverter costs after the Trump administration in September 2018 slapped a 10% import tariff on Chinese inverters as part of its move to place tariffs on \$200 billion of Chinese goods. The inverter tariff will make it difficult for the big Chinese inverter companies such as Huawei and Sungrow to achieve larger market penetration into the U.S. with inverters they manufacture in China. The inverter tariff could rise to 25% if the U.S. and China do not resolve their trade differences before President Trump's March 1 deadline for a trade deal.

## SOLAR PV GROWTH OUTLOOK (CONTINUED)

### Japan solar growth remains slow after post-Fukushima solar boom

Solar power surged in Japan after the Fukushima nuclear disaster in 2011 due to encouragement from a generous government feed-in-tariff (FIT). Japan solar installs during the post-Fukushima solar boom soared by +77% in 2012, +227% in 2013, +46% in 2014, and +16% in 2015.

However, the Japanese government then started cutting the feed-in-tariff to reduce subsidy costs, which caused solar growth to fall back to more sustainable levels. Solar installs fell by -28% in 2016 and by -8% in 2017 to 6.8 GW, which was well below the peak of 11.2 GW seen in 2015, according to BNEF.

For the 2019 fiscal-year beginning in April, the Japanese government in early January announced a -22% cut in the solar tariff to 14 yen/kWh (\$0.129) from 2018's 18 yen rate. The government also said it will reduce the minimum capacity for solar projects required to be awarded with auctions to 500 kW from 2 MW.

For 2018, BNEF estimates that Japan solar installs fell by -8% to 6.8 GW. BNEF is forecasting a small -3% decline for Japanese solar installs in 2019 followed by a +4% rise in 2020.

### India solar boom runs into obstacles

The Indian government is pushing solar very hard as part of its goal of modernizing India's infrastructure, boosting its global business competitiveness, and providing electricity in rural areas to currently non-electrified households. The government has a goal of installing a cumulative 100 GW of solar by 2022, consisting of 60 GW of large-scale solar and 40 GW of rooftop solar.

The 100 GW target is about three times India's cumulative installed solar capacity of 32 GW as of the end of 2018. To meet that target, India would need to install an average of 17 GW of solar per year over the next four years (2019-22).

India's solar installs in 2018 grew by +7% to 11.0 GW, slowing from the torrid growth rates of +94% in 2017, +156% in 2016, and +120% in 2015. BNEF is forecasting that India solar's growth will revive by +32% to 14.5 GW in 2019 and +22% to 17.7 GW in 2020.

Solar accounted for about 45% of new Indian electricity generation installed in 2017, easily taking first place as the most popular new electricity generation source, according to Mercom Capital. Wind was a distant second at about 20% of new capacity.

India's solar growth in 2018 slowed due to (1) increased solar module costs from the 25% safeguard tariff that India's government implemented on July 30, 2018, (2) slow payment of subsidies to developers installing rooftop solar, and (3) delays in

grid connections.

Regarding the tariff, the Indian government as of July 30, 2018 implemented a 25% safeguard tariff on modules imported from developed countries, or from China or Malaysia. The only developing countries of note that were excluded from the tariff were Thailand, Indonesia, Vietnam and the Philippines. The 2-year tariff starts out at 25% for the first year (30-Jul-2018 to 29-Jul-2019) and then steps down to 20% for the next 6-month period (30-Jul-2019 to 29-Jan-2020) and to 15% for the final 6-month period (30-Jan-2020 to 29-Jul-2020).

The safeguard tariff was imposed to prevent the "threat of serious injury" to domestic solar module producers from import competition. Prior to the tariff, India imported 90% of its modules from China and Malaysia. The government hopes that the new tariff will allow a domestic solar manufacturing industry to develop, although that seems unlikely since there are few domestic Indian solar companies that will be able to produce at the scale necessary to support India's ambitious solar installation goals. In addition, the new tariff lasts only two years, which means the tariff wouldn't even be in effect by the time that new Indian solar factories could be built.

### European solar growth expected to accelerate

The outlook for European solar improved significantly after the EU in September 2018 ended its anti-dumping duties against solar modules imported from China and the associated minimum import price (MIP) scheme. The EU's MIP scheme had been in place since 2013 when the EU tried to protect local European solar manufacturers from Chinese competition.

However, the MIP scheme simply raised the cost of solar modules for European solar installers and led to very slow growth for European solar installs over the past several years. In addition, the MIP scheme failed in its mission of protecting European solar manufacturers from Chinese competition because there is actually less solar manufacturing in Europe now than there was before the MIP scheme was adopted.

The end of the EU's MIP scheme is a "watershed moment" for the European solar industry, according to Dr. Christian Westermeier, president of SolarPower Europe. He said, "By removing the trade duties, the European Commission has today lifted the single biggest barrier to solar growth in Europe. The Commission's move to end the trade measures is unquestionably the right one for Europe. We expect to see a significant increase in solar jobs and deployment -- which will only propel the energy transition in Europe."

The end of the MIP scheme, combined with the sharp drop in solar module prices that resulted from the China-531 order, has allowed solar to reach grid-parity in a growing portion of Europe. Europe is moving quickly towards competitive auctions and private development without subsidies. SolarPlaza reported

## SOLAR PV GROWTH OUTLOOK (CONTINUED)

that 2.5 GW of subsidy-free solar was announced in the first six months of 2018 just in Portugal, Spain, Italy and France. In Spain, there is a pipeline of 29 GW of subsidy-free solar projects in the planning or construction stage, including 3.9 GW tendered by the government, according to Spain's national solar trade group, UNEF.

Spain's Energy Minister Jose Dominguez Abascal said at a London conference in late 2018, "We are not thinking of subsidies at all. At this moment, the cheapest way of producing electricity in Spain is the sun. It's much cheaper than any other form of energy. At this moment in Spain there are gigawatts that are under construction without any knowledge of the government."

European solar growth is also expected to show solid growth in coming years due to the need to meet renewable energy targets. The European Parliament in 2018 raised the EU renewable energy target for 2030 to 32% from 27% and also made the target binding on EU members. The EU is relying heavily on its renewables target to meet its pledge under the UN Paris climate agreement to cut its greenhouse gas emissions by 40% by 2030 from 1990 levels.

European solar growth (including the UK) in 2018 showed strong growth of +37% to 6.9 GW, according to BNEF. BNEF is expecting even stronger growth of +87% to 13.0 GW in 2019 due to lower solar module prices from the end of the MIP program and the general global drop in solar prices.

Germany continued to be the largest solar player in Europe by far with 3.2 GW of installs in 2018, up by +88% from 1.7 GW in 2017 (BNEF). German 2018 installs were still less than half of its 2012 record high of 7.6 GW. France was the second largest European solar player in 2018 with growth of +52% to 1.4 GW. The Netherlands was third with a +40% increase to 982 MW.

### Middle East and North Africa are coming on strong

Solar growth is expected to be strong in coming years in the Middle East, North Africa, and Turkey. This region installed 4.5 GW of solar in 2018, up by 36% from 3.3 GW in 2017, according to BNEF. That strong growth will continue with BNEF forecasting growth of +22% to 5.5 GW in 2019 and +15% to 6.3 GW in 2020.

There are utility-scale auction programs in Algeria, Morocco, Turkey, UAE and Egypt, according to BNEF. Solar is booming in Turkey, which saw growth in 2017 of +279% to a record high of 2.15 GW, although growth in 2018 slowed by -8% to 1.98 GW.

Saudi Arabia will tender 2.25 GW of solar capacity during 2019, according to Saudi Arabia's Renewable Energy Project Development Office. Saudi Arabia has an ambitious long-term target of building its cumulative solar capacity to 20 GW by 2023 and 40 GW by 2030. Saudi Arabia is seeking to produce a large amount of its electricity from solar in order to reduce its reliance on burning oil for electricity, thus conserving its oil reserves and raising the amount of revenue it can earn by selling its oil to overseas buyers.

### Latin America poised for strong growth

Solar is poised for strong growth in South America. Annual solar installs in Latin America will triple between 2017 and 2022 and a cumulative 46 GW of solar will be installed over that period, according to Wood Mackenzie. By 2022, Latin America will account for 10% of global PV demand, according to Wood Mackenzie.

## SOLAR JOBS

U.S. solar jobs in 2017 fell by -3.8% to 250,271 jobs from the record high of 260,077 jobs in 2016, according to the "National Solar Jobs Census 2017" published by The Solar Foundation.

Despite the 2017 decline, the U.S. solar industry during the 5-year period of 2012-2017 added a net total of 131,000 jobs to the U.S. economy, rising by +16% annually and by a total of +110% over the five year period.

Solar employment in the five years through 2017 grew nine times faster than the +1.8% annual growth rate of the U.S. economy, according to the Solar Foundation, illustrating how the solar industry has made a substantial contribution to the U.S. labor market.

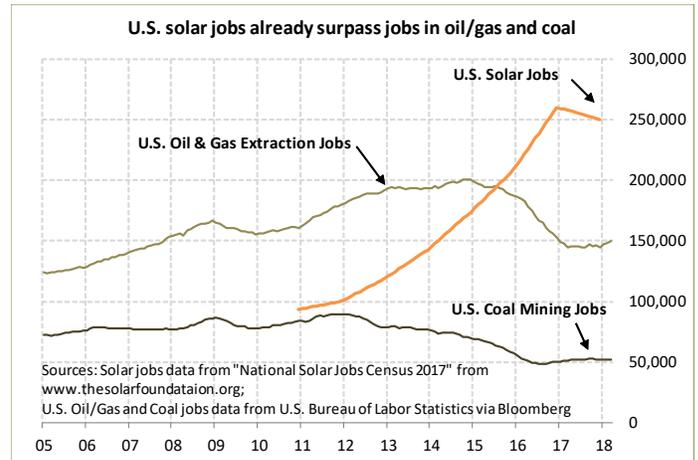
About 78% of U.S. solar jobs are in the demand-side sectors such as installation, sales & distribution and project development. Meanwhile, manufacturing accounts for only 15% of total solar jobs, according to the Solar Foundation.

The decline in solar jobs in 2017 was due to slower solar installs after the growth spike seen in 2016. In addition, solar jobs retrenched in 2017 on uncertainty ahead of the Trump administration's 30% solar tariff on imported cells/modules, which raised the cost of solar projects and reduced the number of project installs.

Despite the 2017 job decline, solar jobs in the U.S. still substantially exceed those in the fossil fuel industries. Specifically, the 250,271 jobs in the solar sector far exceed the 150,200 direct jobs in the oil/gas extraction industry and 52,100 direct jobs in the coal mining industry, according to figures from the U.S. Bureau of Labor Statistics (see chart on the right).

Globally, solar is a huge employer with 3.37 million solar jobs worldwide in 2017, up by +9% from 3.09 million in 2016, according to the "Renewable Energy and Jobs--Annual Review" from the International Renewable Energy Agency (IRENA).

China is way ahead of the U.S. in solar jobs with a total of 2.2 million jobs in 2017 due to its much larger installation and manufacturing solar sector, according to the IRENA report. Japan also has more solar jobs than the U.S. at 272,000, according to IRENA.



## SOLAR PV ANNUAL NEW INSTALLATIONS -- 2018

New global solar PV installations in 2018 grew by +10% yr/yr to a record 109 gigawatts (GW), according to Bloomberg New Energy Finance (BNEF). The 2018 growth rate of +10% followed growth rates of +32% in 2017 and +34% in 2016. Global solar PV installations have grown at a compounded annual rate of +21% over the last 5 years and have risen 6-fold from 2010.

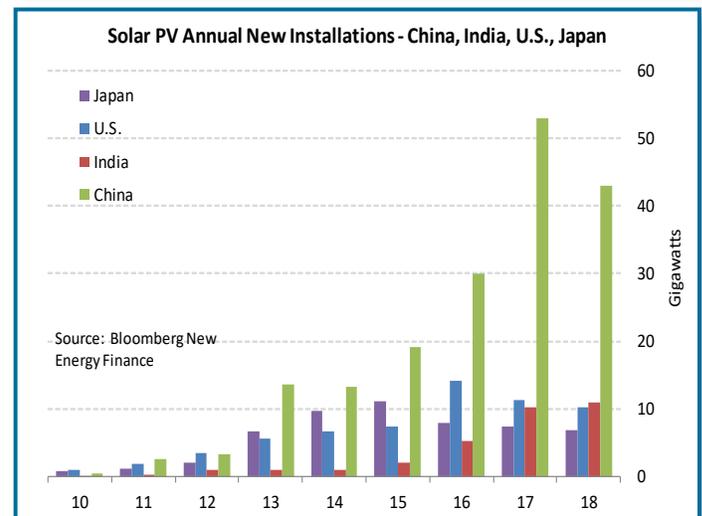
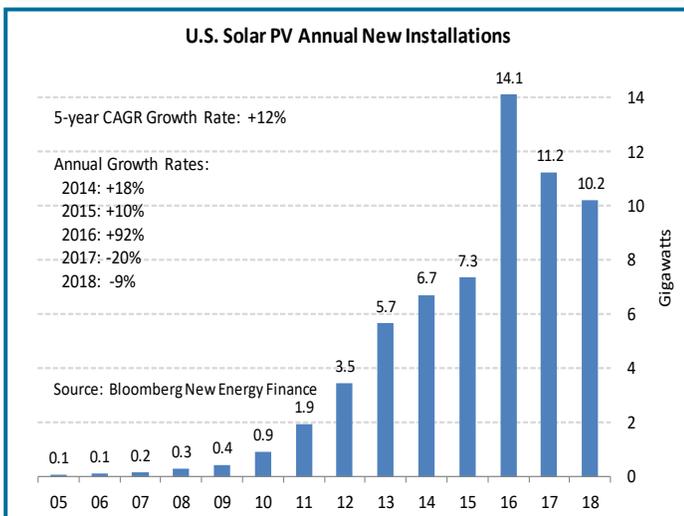
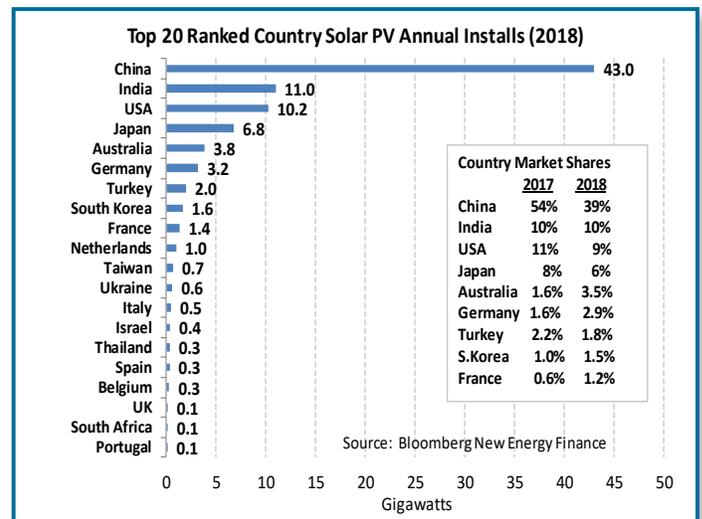
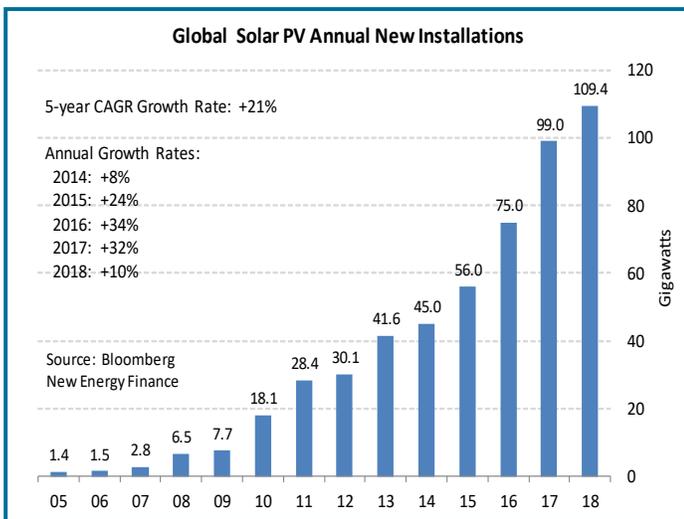
In 2018, China led the world for annual solar PV installs for the fifth straight year with 43 GW of installs, down by -19% from the 53 GW in 2017, according to BNEF. India passed the U.S. to reach second place with 11.0 GW of installs, up by +7% yr/yr. The U.S. fell into third place in 2018 with 10.2 GW of installs, down by -9% yr/yr from 11.2 GW in 2017. Japan remained in fourth place with 6.8 GW of installs, down by -8% yr/yr. Australia remained in fifth place with growth tripling to 3.8 GW.

There were nine countries in 2018 with installs above 1 GW versus only seven such countries in 2016 and 2017, illustrating

the geographical spread of solar. It was also notable that China's share of total global installs fell to 39% in 2018 from a hefty 54% in 2017, illustrating the more balanced world solar growth in 2018.

Solar growth in Europe in 2018 was generally strong with Germany up +88% yr/yr at 3.2 GW, France up +52% yr/yr to 1.4 GW, Italy up +14% at 468 MW, and Spain up +141% at 325 GW (BNEF). However, UK solar in 2018 fell sharply by -84% to 145 MW.

U.S. solar PV installations in the five years through 2018 grew by a compounded annual rate of +12% and were up 11-fold from 2010, according to BNEF. The states with the largest amount of new PV solar installations in 2017 were California (-50% to 2.6 GW), North Carolina (+18% to 1.2 GW), and Florida (+85% to 749 MW), according to GTM Research. The states with the largest installed cumulative base of solar power at the end of 2017 were California, North Carolina, Arizona, Nevada, New Jersey, Massachusetts, Texas, Utah, Georgia, and Florida.



## SOLAR PV CUMULATIVE INSTALLATIONS THROUGH 2018

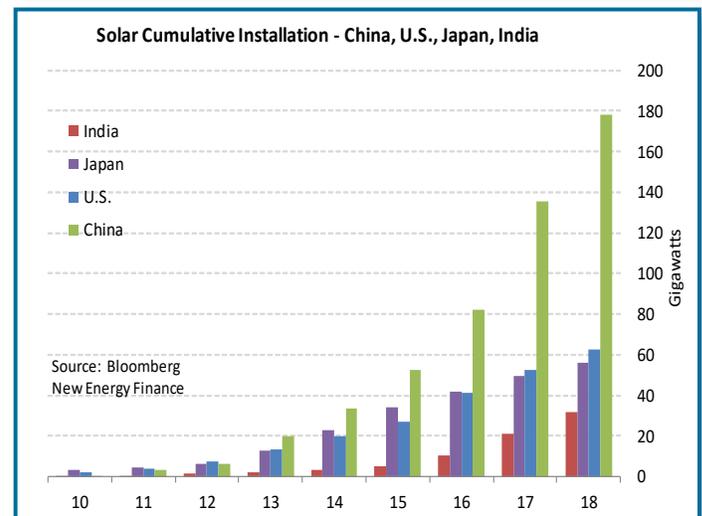
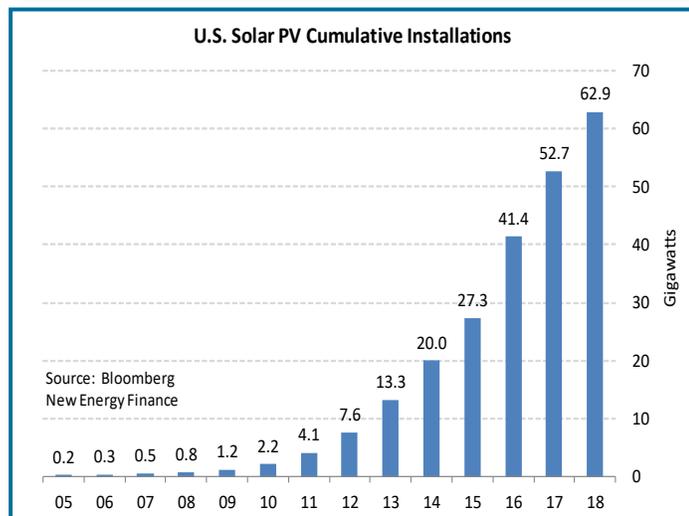
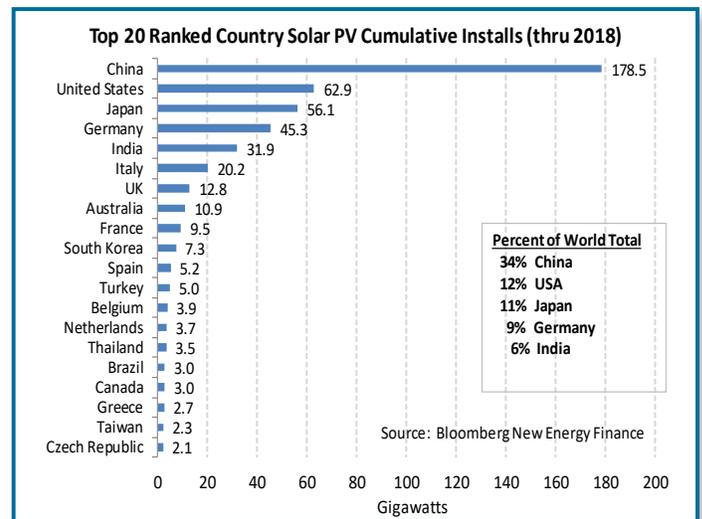
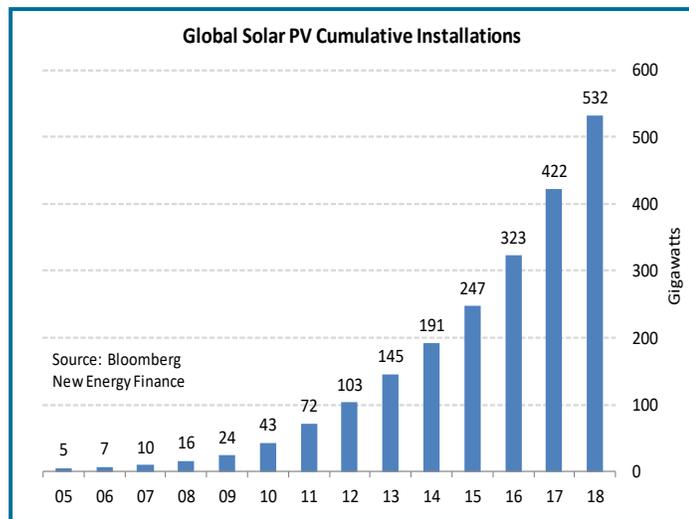
The amount of cumulative PV electricity generation capacity across the world grew sharply by +26% yr/yr to 532 GW in 2018, according to Bloomberg New Energy Finance (BNEF). In the last five years, global cumulative solar PV electricity generation capacity increased by more than 3-fold from 145 GW in 2013 to 532 GW in 2018, representing a compounded annual growth rate of +30%.

China continued to be the world's leader for cumulative solar capacity at 178 GW, according to BNEF. China at the end of 2018 accounted for 34% of the world's solar PV capacity. In the past five years, China's cumulative installed solar capacity soared by 9-fold from 20 GW in 2013 to the 2018 level of 178 GW, representing a 5-year compounded annual growth rate of 55%.

The U.S. in 2018 remained in second place in cumulative solar installs. U.S. solar electricity capacity in 2018 rose by +19% to 63 GW, representing 11.8% of world capacity. U.S. cumulative solar electricity capacity over the past five years rose by more than four-fold to 63 GW from 13 GW in 2013 and showed a compounded annual growth rate of +37%.

Japan remained in third place for the fifth straight year. Japan's cumulative solar capacity in 2018 rose by +14% to 56 GW, representing 10.5% of world capacity. Japan's cumulative solar capacity in the past 5 years has risen by more than 3-fold to 56 GW from 13 GW in 2013, representing a 5-year compounded annual growth rate of 34%.

Germany in 2018 remained in fourth place with 45 GW of cumulative solar PV capacity, up by +8% from 2017. Germany's cumulative solar capacity in the past 5 years has risen 1.3-fold to 45.3 GW from 35.5 GW in 2013. Germany at the end of 2018 accounted for 8.5% of the world's total solar PV capacity.



## SOLAR PRICING

World prices for solar cells and modules in late-2018 and early-2019 stabilized after falling sharply during mid-2018 on the China-531 order by the Chinese government to reduce solar subsidy support. The price of multicrystalline solar cells fell by -52% from May 2018 to a record low of 11 cents per watt at the end of September 2018, and has since stabilized at 12 cents per watt, according to Bloomberg New Energy Finance (BNEF). Solar cell prices have plunged by a total of -85% since mid-2011.

The average price of silicon solar modules dropped by -26% from May 2018 to a record low of 21.7 cents per watt in November 2018, and has since rebounded slightly higher to 21.9 cents, according to PV Insights. Solar module prices have fallen by -27% on a year-on-year basis and by -82% from mid-2011.

The price of thin-film modules fell by -23% from May 2018 to a record low of 24.3 cents per watt in November 2018 and has since rebounded slightly higher to 24.6 cents, according to PV Insights. Thin-film module prices have fallen by -25% on a year-on-year

basis and by -74% since mid-2011.

Spot polysilicon prices fell to a record low of \$9.55 per kg in late December 2018 and then rebounded slightly higher to \$9.57 in early January, according to BNEF. Polysilicon prices have fallen by -39% since May 2018 and by -42% on a year-on-year basis. The decline in polysilicon prices is a key factor in allowing solar cell and solar module prices to decline since polysilicon is the main raw material for most solar cells.

Solar prices in the second half of 2016 fell sharply mainly because of module oversupply after the solar install spikes seen in China and the U.S., which were caused by developers trying to beat respective subsidy reduction deadlines. Solar pricing during 2017 and early 2018 moved mildly lower in line with its natural long-term downward trend that is the result of lower production costs from technology advances and economies of scale in manufacturing. Solar prices then fell sharply after May 31, 2018 when the Chinese government with its China-531 order reduced its subsidy support.

