MAC Solar Index

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SOLAR SECTOR UPDATE

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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 to a 1-year high in May 2019 from the 2-year low seen in October 2018. The index is currently up +38% on the year, more than reversing 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 2018-19 and the fact that solar has now reached grid parity in many cases, (2) the stabilization of solar cell and module prices in late 2018 and early 2019 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 3 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 reasonable valuation level of solar stocks.

Bearish factors for solar stocks include (1) low Chinese solar installs in the first half of 2019 as China transitions to its new solar policy that should produce strong solar installs in the second half of 2019, (2) the continued negative effect on U.S. solar from the Section 201 tariff 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 are trading at reasonable valuation levels compared with the broad market. The estimated positive P/E of 17.79 for the companies in the MAC Solar Index is mildly above the comparable figure of 16.95 for the S&P 500 index, according to Bloomberg data. However, the price-to-book ratio of 1.54 for the companies in the MAC Solar Index is far below the 3.27 ratio for the S&P 500. The price-to-sales ratio of 1.14 for the MAC Solar Index is far below the 2.09 ratio for the S&P 500.

Solar stocks rally on expectations for solid 2019 solar growth

Solar stocks in early 2019 have rallied sharply due to (1) the recovery of global stock markets in early 2019 after the sharp downside correction seen in Q4, (2) the recovery of the global solar industry after the blow from China's subsidy cut in May 2018, and (3) expectations for strong global solar growth in the second half of 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 natural gas and wind.

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. There is now a big pipeline of global solar projects that supports expectations for a strong year

for solar installs 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 growth is expected to be strong over the next several years as developers take advantage of the investment tax credit (ITC) before it progressively 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-plus-storage goes big

The combination of solar plants with battery storage systems ("solar-plus-storage") is taking off quickly in the U.S. and the size of the battery systems is multiplying. Florida Power & Light is planning to build what would be a record-sized battery plant with 409 MW of capacity. The battery plant will be powered by an existing solar plant that has 900 MW of capacity. The battery plant will be built by 2021 and will help accelerate the decommissioning of two nearby natural-gas power plants.

Not to be outdone, the Electric Reliability Council of Texas, which operates most of the Texas electricity grid, will build an even larger 495 MW battery storage system in Texas. The storage system will be powered by a newly-built 495 MW solar plant.

Meanwhile in Hawaii, regulators approved seven solar-plus-storage projects totaling 262 MW of solar and 1.048 GWh of battery storage. The projects are being built by Hawaii's utility company, Hawaiian Electric, 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, which is currently Hawaii's primary means of generating electricity. The average price of 9 cents is also 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 even 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.

U.S. raises tariffs on Chinese inverters to 25%

President Trump on May 10 announced a hike in the penalty tariffs on Chinese solar inverters to 25% from 10%. Solar inverters are electrical devices that convert the direct current (DC) from solar panels into the alternating current (AC) that is used on the grid. Inverters were included in the Trump administration's hike in the penalty tariff to 25% from 10% on $200 billion worth of Chinese goods.

However, the tariff hike on Chinese inverters is not likely to have much impact on the U.S. solar market since U.S. solar developers have already moved away from Chinese-built inverters due to the initial 10% tariff that was imposed in September 2018.

The higher tariff will make it nearly impossible for Huawei Technologies, the world's largest inverter manufacturer, to build a larger market share for U.S. sales. That gives a boost to smaller U.S.-listed inverter manufacturers such as SolarEdge Technologies (SEDG US), Enphase Energy (ENPH US), and European-listed SMA Solar Technology (S92 GR).

Separately, the Trump administration is threatening to slap a 25% penalty tariff on another $300 billion of Chinese goods as soon as June if there is no US/Chinese trade agreement. Batteries are on the list of goods that would be subject to that 25% tariff. If batteries get hit with a tariff, that could slow the rapid pace of solar-plus-battery installations in the U.S. due to a higher cost of the batteries. The U.S. currently imports about 40% of its lithium-ion batteries from China, although most of those batteries are for end-markets other than grid-storage. The good news is that China currently supplies less than 5% of the batteries used in large-scale energy storage products, according to BNEF.

The Trump administration in early 2018 already slapped tariffs on most imported solar modules and cells, which means there isn't much more damage that can result for solar cells and modules from the US/Chinese trade war.

SOLAR PV GROWTH OUTLOOK

Solar is expected to rebound in 2019 after the temporary obstacles seen in 2018. Bloomberg New Energy Finance (BNEF) is forecasting that solar installs in 2019 will grow by +16% to 125 GW from 108 GW in 2018. For its part, IHS Markit is forecasting that world solar installs in 2019 will grow by a even stronger rate of +25% to 129 GW from their estimate of 103 GW in 2018. See page 8 for solar growth charts.

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 (+32%). In 2018, world solar growth rose by only +9% to 108 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 is set to resume its strong growth rate in coming years as low solar costs boost long-term demand for solar. In addition, past boom/bust solar cycles caused by erratic government subsidy policies should soon become a thing of the past as solar becomes so cheap that subsidies become unnecessary. BNEF is forecasting +12% annual solar growth through 2040, with solar capacity up by 8-fold to 4,500 GW by 2040 from 526 GW in 2018.

Solar will account for about 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 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, easily beating coal, nuclear, natural gas, and wind.

Optimism grows for Chinese solar in 2019 after the China-531 disruption in 2018

China's solar growth is expected to resume in the second half of 2019 after the year-long disruption caused by the sharp cut-back in subsidies that was announced back in May 2018. China is beginning to do away with subsidies and is encouraging the development of non-subsidized solar projects that are equal to or cheaper than the cost of coal. China can afford to move towards unsubsidized solar since the cost of solar has dropped so dramatically in recent years that solar has achieved grid-price parity with other sources of electricity generation such as coal without the need for subsidies.

Separately, Chinese government officials are expected to soon announce a higher 2020 solar target. Chinese officials at a symposium with industry members in late 2018 suggested that the 2020 solar target might be raised to 270 GW from the current level of 210 GW. China at the end of 2018 had installed solar capacity of 180 GW, implying annual solar targets of around 45 GW for 2019 and 2020.

Chinese solar installs in 2018 fell by -16% to 44 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 most solar subsidies, with utility-scale solar capped at 40 GW and roof-top distributed generation (DG) capped at 10 GW.

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 slow solar growth in areas where there is electricity overcapacity and curtailment.

Prior to the China-531 order, the subsidies for solar were so generous that Chinese solar installs in 2017 ballooned by +76% to 53 GW and accounted for a hefty 54% of all world installs. However, the China-531 order then 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 Chinese government spent the second half of 2018 and early 2019 coming up with a new solar policy that is focused on moving the country to unsubsidized solar. The move away from subsidies should be a long-term positive for the Chinese solar industry since the industry should soon be able to grow in a more predictable manner with improved and stable profit margins, as opposed to the boom-bust days of the past that were caused by erratic government subsidy policies. Without subsidies, the solar industry should be able to more closely match end-user demand, eliminating the small and less competitive players that can only compete when there are generous subsidies. The industry should then become dominated by the large players with the best technology, the lowest production costs, and stable profit margins.

The Chinese government has been well-meaning with its subsidy support in recent years, but its overly-generous subsidy support resulted in overproduction, losses, and bankruptcies for the solar

SOLAR PV GROWTH OUTLOOK (CONTINUED)

industry. Those generous solar subsidies were at least successful, however, in allowing the solar industry to achieve big economies of scale, thus allowing solar costs to drop sharply and become competitive with other sources of electricity.

The Chinese government in April 2019 finally laid out its new plan whereby officials first approve zero-subsidy solar projects and then move on to approve solar projects with subsidies.

The slow roll-out of China's solar transition in late 2018 and early 2019 caused China's solar installs to be weak at only 5 GW in Q1 2019. Weak growth of about 5 GW is also expected in Q2, leading to 1H2019 Chinese solar installs of only about 10 GW.

However, Chinese solar installs are then expected to surge in the second half of 2019 as solar developers ramp up both subsidized and unsubsidized projects that were delayed by the government's new policy roll-out. In fact, solar installs in 2H2019 are expected to surge to 25-30 GW, leading to the consensus for full-year 2019 installs of 35-40 GW. That would be down from 44 GW in 2018 and the record of 53 GW in 2017.

China's government will provide a variety of measures to encourage developers to build unsubsidized solar projects. For example, the projects will receive guaranteed long-term 20-year government off-take electricity-generation contracts that will give the solar projects revenue-certainty and will thus make it easier to obtain bank financing. The unsubsidized solar projects will also receive priority dispatch versus other types of electricity generation, thus reducing the risk that the solar project will be subject to curtailment.

Unsubsidized solar projects will also receive (1) guaranteed grid connections, (2) reduced land costs and transmission fees, and (3) access to prioritized financing from China's large state-owned commercial banks and Chinese development banks.

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. The projects will also receive Renewable Energy Credits (RECs) for their electricity generation, which will boost their income since they can sell those RECs.

The unsubsidized solar 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 of the program are later dropped such as the 20-year fixed tariff and guaranteed dispatch.

The Chinese government on May 22 approved the first batch of zero-subsidy renewable projects, which included 14.8 GW of solar and 4.5 GW of wind. Project developers can now move ahead with the construction of these solar projects.

Now that the unsubsidized projects have been approved, government officials can move ahead with approving solar projects that will receive a subsidy. The government will start allocating subsidies on a competitive auction basis, meaning that the subsidies will go the lowest-cost projects. That auction system will support low-cost producers and will encourage the cost of solar to decline further and become even more competitive.

The government said it will allocate a total of 3 billion yuan of subsidies ($440 billion) in 2019, which will support about 35.5 GW of solar installs. Of that total, 2.25 billion yuan will go to large-scale solar projects (utility and industrial) with capacity of about 32 GW. The remaining 0.75 billion yuan will be allocated to residential solar projects with capacity of 3.5 GW.

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

U.S. solar growth is expected to improve in coming years due to (1) increased solar demand stemming from the sharp drop in solar costs and the strong competitiveness of solar compared with other sources of new electricity generation, (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) that progressively steps down beginning in 2020 to 10% by 2022 and beyond for all solar projects expect those installed by homeowners.

U.S. solar installs in 2019 will grow by +5.5% to 11.6 GW from 11.0 GW in 2018, according to BNEF. The expected 2019 growth rate of +5.5% would nearly match the +5.6% growth rate seen in 2018 and would be much better than the -22% decline seen in 2017 to 11.0 GW from the record high of 14.1 GW posted in 2016 (BNEF).

Solar accounted for 29% of all new U.S. electricity generation capacity installed in 2018, behind natural gas at 54% but well ahead of wind at 16%, according to Wood Mackenzie. Other sources of new electricity generation such as coal and nuclear were negligible in 2018.

U.S. solar installs in 2019 and 2020 are expected to strengthen as solar project managers 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, or spend 5% of the project's total cost, by the end of the year in question, as opposed to the previous requirement that 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

SOLAR PV GROWTH OUTLOOK (CONTINUED)

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 modules.

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 solar installs in 2017 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 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.

The initial Section 201 import tariff of 30% in 2018 stepped down to 25% in February 2019 and will fall farther to 20% in February 2020, 15% in February 2021, and zero in February 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 solar import tariff, U.S. utility solar procurement in 2018 was strong because the announcement of the Section 201 tariff in January 2018 at least removed the uncertainty from the marketplace that hurt solar installs in late 2017 and early 2018. Utility solar was also supported in 2018 by the sharply lower cost of solar projects that resulted from China's May 2018 subsidy cut.

U.S. utilities installed 6.163 GW of solar in 2018, down -3% from 2017, according to Wood Mackenzie. However, there was a large pipeline of 23.9 GW of contracted utility solar projects at the end of 2018, which means there is a very strong pipeline for finished projects in 2019 and 2020. Utility solar accounted for 58% of U.S. solar installs in 2018, running well ahead of residential and non-residential (commercial, industrial and community) installs.

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. Wood Mackenzie says that voluntary procurement is now the largest driver of new power purchase agreements (PPAs) and will drive 51% of U.S. solar capacity additions in 2019.

On the tariff front, the U.S. solar sector is also dealing with some disruptions in the solar inverter market caused by tariffs. Solar inverters are electrical devices that convert the direct current (DC) from solar panels into the alternating current (AC) that is used on the grid.

The Trump administration in May 2019 raised the tariff on inverters imported from China to 25% from the 10% level that was first imposed in September 2018 as part of the U.S. move to slap tariffs on $200 billion of Chinese products.

The inverter tariff, however, is not having much direct impact on the U.S. solar sector because inverters can easily be sourced outside of China. Yet the inverter tariff will make it difficult for the big Chinese inverter companies such as Huawei Technologies and Sungrow Power Supply to build their market share in the U.S. Huawei is also suffering from the Trump administration's move to put the company on the U.S. trade blacklist, which means that U.S. companies must obtain a special license to either buy products from or sell products to Huawei.

Japan solar growth expected to improve

Solar power surged in Japan after the Fukushima nuclear disaster in 2011 due to a generous government solar feed-in-tariff (FIT) as the government sought to reduce the nation's reliance on nuclear energy. 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, by -8% in 2017, and by another -8% in 2018 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, thus increasing the use of auctions to award solar projects.

For 2019, BNEF is forecasting a big +26% increase in Japanese solar installs to 8.6 GW, followed by a -10% decline in 2020 to 7.7 GW. Solar installs in Japan are expected to be strong in the next two years as developers seek to beat step-downs in solar subsidies.

SOLAR PV GROWTH OUTLOOK (CONTINUED)

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 expanding electricity access in rural areas. The government has set 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 +8% to 11.1 GW, slowing from the torrid growth rates of +94% in 2017, +156% in 2016, and +120% in 2015. BNEF is forecasting India solar's growth at +9% to 12.2 GW in 2019 and at +18% to 14.3 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) the slow payment of government 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 hoped that the new tariff would 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 until July 2020, which means the tariff would likely no longer be in effect by the time 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 ended 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 succeeded only in raising the cost of solar modules for European solar installers and led to very slow growth for European solar installs over the past several years. The MIP scheme failed in its mission of protecting European solar manufacturers from Chinese competition because the amount of solar manufacturing in Europe ended up falling relative to where it 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 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.

SOLAR PV GROWTH OUTLOOK (CONTINUED)

In addition, Germany in January 2019 announced a commitment to close all its 84 coal-fired power plants by 2038. Coal currently accounts for about 40% of Germany's electricity. Germany already has a commitment to phase out all its nuclear power plants by 2022 with 12 of the nation's 19 plants already closed down. Those commitments, combined with new renewable resources, mean that Germany by 2040 will get 65-80% of it power from renewable sources, up from 41% in 2018. Germany in 2018 received about 20% of its electricity from solar. Germany provides a valuable case study about how much more solar can exist on the grid than many people assume.

Europe's focus on boosting its reliance on renewables will come mainly from solar since 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 auctioned in October 2018 and all of the 210 MW of renewable power auctioned in April 2019. The average winning solar bid was an impressively-low 52.7 euros ($59.0) per MWh in the Nov 2018 auction and 56.6 euros ($63.4) per MWh in the April 2019 auction. In France, an auction of 200 MW of renewable capacity in November 2018 was also won by all solar projects and no wind with an average price of 54.9 euros ($61.5) per MWh.

European solar growth (including the UK) in 2018 showed strong growth of +38% to 6.9 GW, according to BNEF. BNEF is expecting even stronger growth of +112% to 14.7 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 2.9 GW of installs in 2018, up by +77% from 1.7 GW in 2017 (BNEF). However, German 2018 installs were still only about one-third of its record high of 8.2 GW seen in 2012.

The Netherlands moved ahead of France into second place in Europe in 2018 by doubling installs to 1.4 GW from 0.7 GW in 2017. France was the third largest European solar player in 2018 with growth of +41% to 1.3 GW. Italy was in fourth place in 2018 with growth of +6% to 435 MW. Spain was fifth place in 2018 with growth of +94% to 262 MW. The UK fell to 6th place in 2018 with a -73% decline to 243 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 from 2017 to 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 PV ANNUAL NEW INSTALLATIONS -- 2018

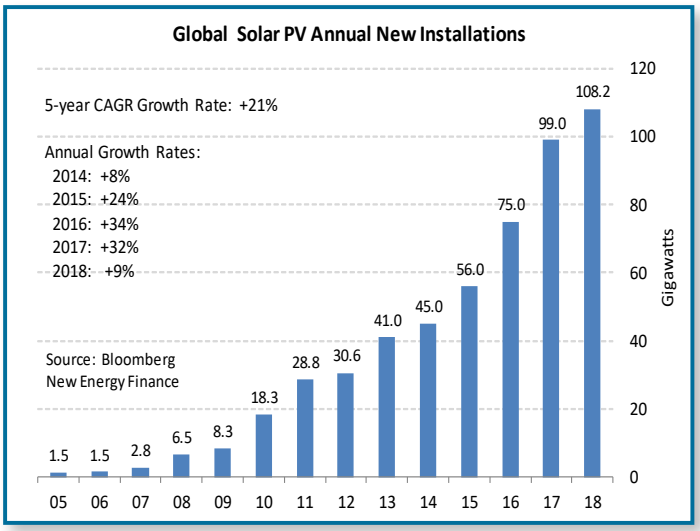
New global solar PV installations in 2018 grew by +9% yr/yr to a record 108 gigawatts (GW), according to Bloomberg New Energy Finance (BNEF). The 2018 growth rate of +9% followed growth rates of +32% in 2017 and +34% in 2016. Global solar PV installations have grown at a compounded annual rate of +21% over the last 5 years and have risen 6-fold from 2010.

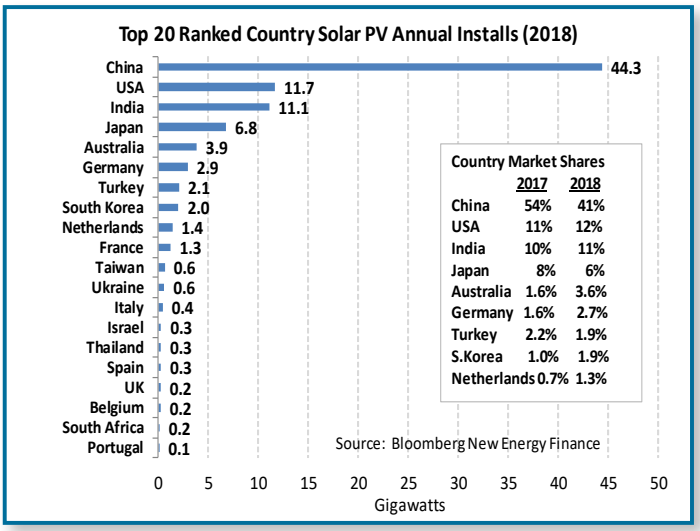
In 2018, China led the world for annual solar PV installs for the fifth straight year with 44 GW of installs, down by -16% from the record high of 53 GW in 2017, according to BNEF. The U.S. remained in second place in 2018 with 11.7 GW of installs, up by +6% yr/yr from 11.0 GW in 2017. India remained in third place with 11.1 GW of installs, up by +8% yr/yr. 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 3.9 GW.

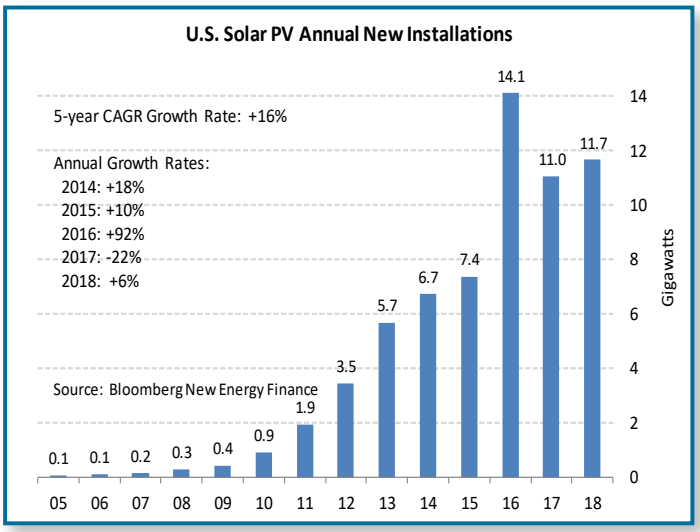
There were ten countries in 2018 with installs above 1 GW versus only seven such countries in 2016 and 2017, illustrating the geographical spread of solar. It was also notable that China's share of total global installs fell to 41% in 2018 from a hefty 54% in 2017, illustrating the more balanced nature of world solar growth in 2018.

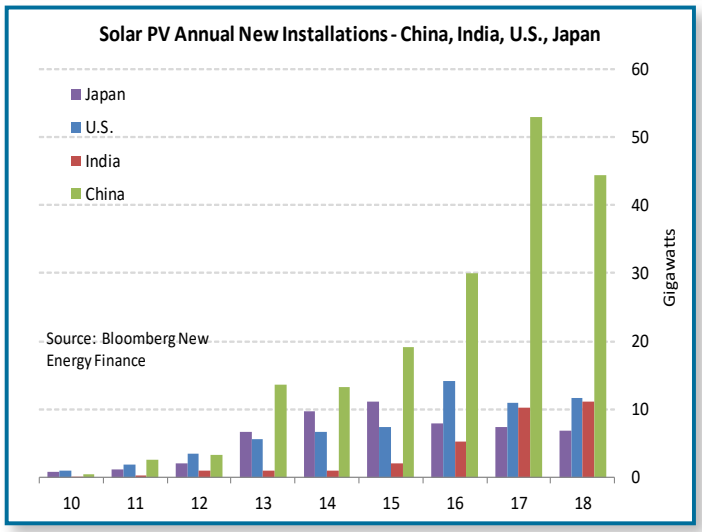
Solar growth in Europe in 2018 was generally strong with Germany up +77% yr/yr to 2.9 GW, Netherlands up +101% to 1.4 GW, France up +41% yr/yr to 1.3 GW, Italy up +6% at 435 MW, and Spain up +94% to 262 MW (BNEF). However, UK solar in 2018 fell sharply by -73% to 243 MW.

U.S. solar PV installations in the five years through 2018 grew by a compounded annual rate of +16% and were up 12-fold from 2010, according to BNEF. The states with the largest amount of new PV solar installations in 2018 were California (+31% to 4.0 GW), Texas (+39% to 996 MW), and North Carolina (-27% to 907 MW), according to Wood Mackenzie. The next 7 largest states for new solar installs in 2018 were Florida, Nevada, New York, New Jersey, Minnesota, Arizona, and Massachusetts, according to Wood Mackenzie.









SOLAR PV CUMULATIVE INSTALLATIONS THROUGH 2018

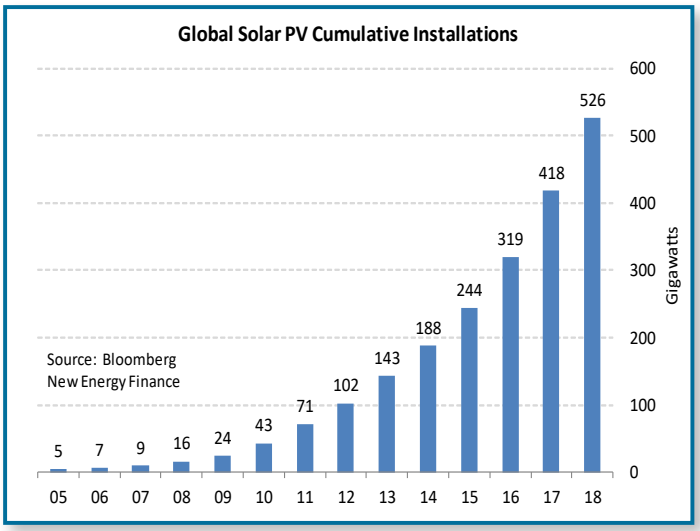
The amount of cumulative PV electricity generation capacity across the world grew sharply by +26% yr/yr to 526 GW in 2018, according to Bloomberg New Energy Finance (BNEF). In the last five years, global cumulative solar PV electricity generation capacity increased by more than 3-fold from 143 GW in 2013 to 526 GW in 2018, representing a compounded annual growth rate of +30%.

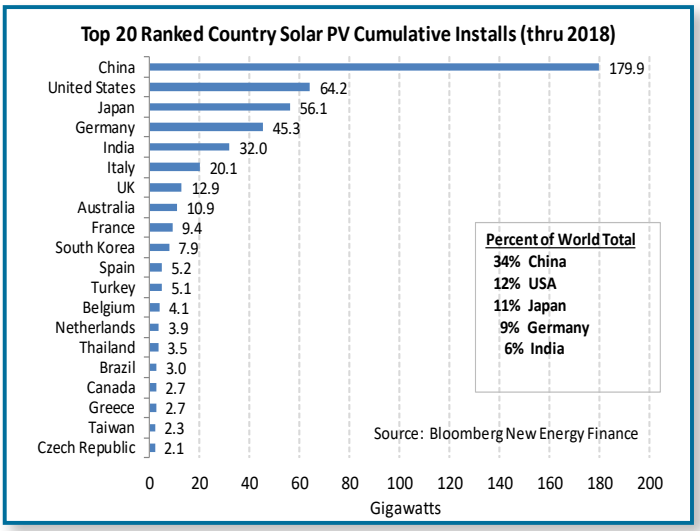
China continued to be the world's leader for cumulative solar capacity at 180 GW, according to BNEF. China at the end of 2018 accounted for 34% of the world's solar PV capacity. In the past five years, China's cumulative installed solar capacity soared 9-fold from 20 GW in 2013 to the 2018 level of 180 GW, representing a 5-year compounded annual growth rate of 55%.

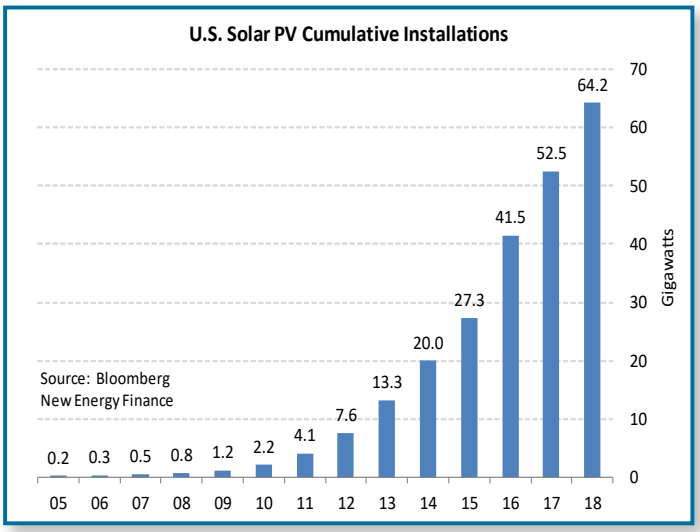
The U.S. in 2018 remained in second place in cumulative solar installs. U.S. solar electricity capacity in 2018 rose by +22% to 64 GW, representing 12.2% of world capacity. U.S. cumulative solar electricity capacity over the past five years rose by more than 4-fold to 64 GW from 13 GW in 2013 and showed a compounded annual growth rate of +37%.

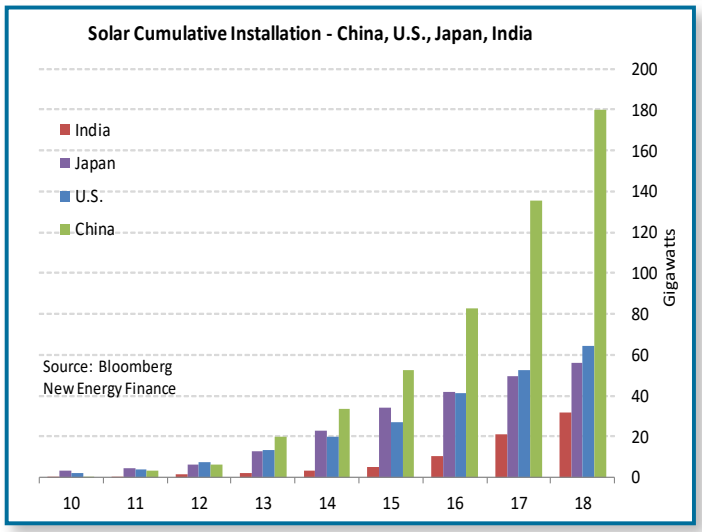
Japan remained in third place for the fifth straight year. Japan's cumulative solar capacity in 2018 rose by +14% to 56 GW, representing 10.7% of world capacity. Japan's cumulative solar capacity in the past 5 years has risen by more than 4-fold to 56 GW from 13 GW in 2013, representing a 5-year compounded annual growth rate of 34%.

Germany in 2018 remained in fourth place with 45 GW of cumulative solar PV capacity, up by +7% from 2017. Germany's cumulative solar capacity in the past 5 years has risen 1.2-fold to 45.3 GW from 36.7 GW in 2013. Germany at the end of 2018 accounted for 8.6% of the world's total solar PV capacity.









SOLAR LCOE PRICING

Solar's electricity cost falls 13% 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).

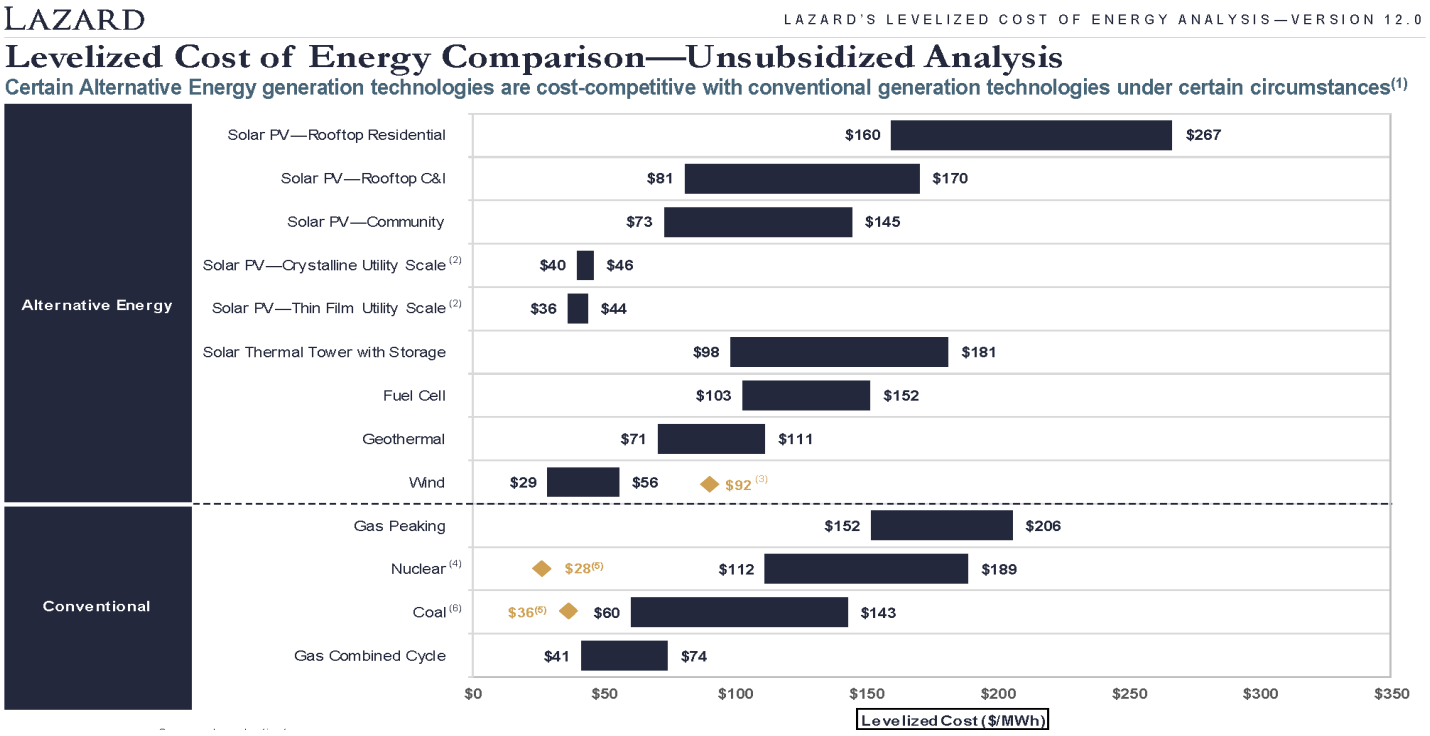
Lazard's latest LCOE report shows that solar PV now easily beats the cost of newly built coal plants ($60-143/MWh), nuclear plants ($112-189/MWh), and gas-peaking plants (($152-206/MWh). The Lazard data shows that in most areas it is no longer economical for a utility to build any new coal or nuclear 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 solar, gas, and wind plants based on economics, with gas being their preference for baseload until battery storage starts to play a bigger role in solving solar's intermittency problem.

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.



PRICING - SOLAR MODULES, CELLS, AND POLYSILICON

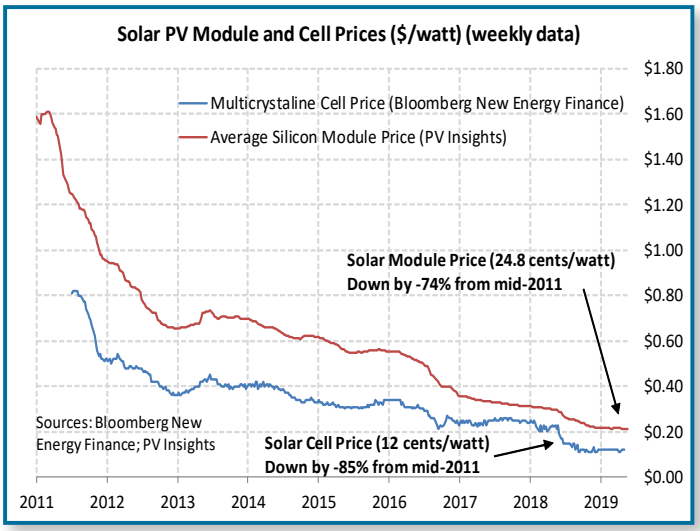
World prices for solar cells and modules in late-2018 and early-2019 stabilized after falling sharply during mid-2018 on the China-531 order by the Chinese government to reduce solar subsidy support. The price of multicrystalline solar cells fell by -52% from May 2018 to a record low of 11 cents per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

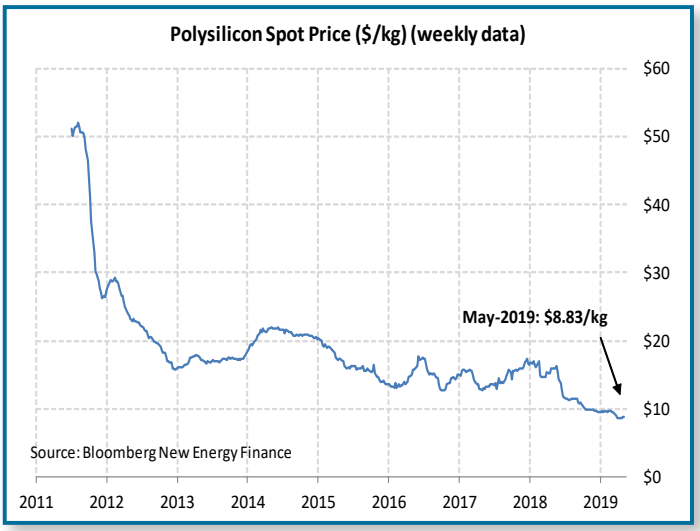
The average price of silicon solar modules dropped by -28% from May 2018 to a record low of 21.3 cents per watt in May 2019, according to PV Insights. Solar module prices have fallen by -83% from mid-2011.

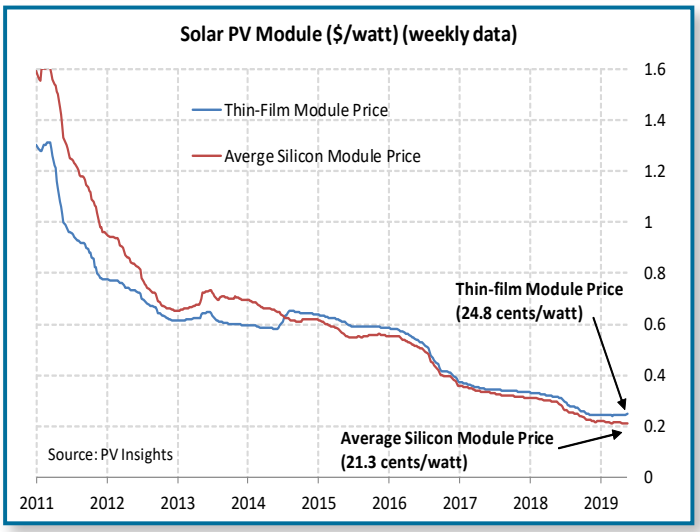
The price of thin-film modules fell by -23% from May 2018 to a record low of 24.3 cents per watt in November 2018 and has since rebounded slightly higher to 24.8 cents, according to PV Insights. Thin-film module prices have fallen by -21% on a year-on-year basis and by -74% since mid-2011.

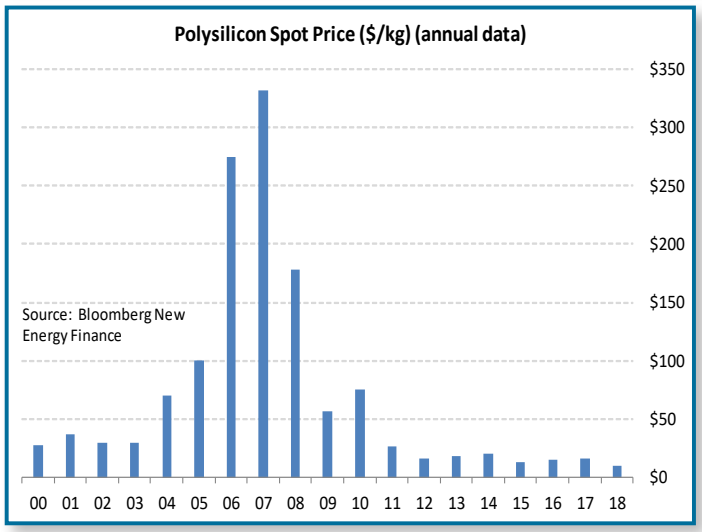
Spot polysilicon prices fell to a record low of $8.57 per kg in late April 2019 and then rebounded slightly higher to $8.83 in early May, according to BNEF. Polysilicon prices have fallen by -39% since May 2018. The decline in polysilicon prices is a key factor in allowing solar cell and solar module 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. Solar prices since late-2018 have stabilized and moved just mildly lower in line with lower production costs and technology advances.









SOLAR JOBS

U.S. solar jobs in 2018 fell by -3.2% to 242,343 jobs from 250,271 jobs in 2017, according to the "National Solar Jobs Census 2018" published by The Solar Foundation. Solar jobs in 2018 fell for the second straight year after the -3.8% decline seen in 2017 from the record high of 260,077 jobs in 2016.

Despite the 2017-18 decline, the U.S. solar industry during the 8-year period of 2010-2018 added a net total of nearly 150,000 jobs to the U.S. economy, rising by +12.6% annually and by a total of +159% over the 8-year period.

Solar employment in the eight years through 2018 grew seven 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 and economy.

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

The decline in solar jobs in 2017 and 2018 was due to slower solar installs after the growth spike seen in 2016. In addition, solar jobs retrenched in 2017-18 due to 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 2017-18 job decline, solar jobs in the U.S. still substantially exceed those in the fossil fuel industries. Specifically, the 242,343 jobs in the solar sector far exceed the 152,500 direct jobs in the oil/gas extraction industry and 52,400 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.