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), has rallied sharply during 2019 and posted a new 4-year high in September. The index has since settled back but is still up 51% on the year.

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 for two-thirds of the world's population, (2) the stabilization of solar cell and module prices in 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 in India, Turkey, Latin America, Middle East, and Southeast Asia (see page 4 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 nine months of 2019 as China shifts its solar policy to phase out subsidies, (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 16.68 for the companies in the MAC Solar Index is well below the comparable figure of 19.12 for the S&P 500 index, according to Bloomberg data. Also, the price-to-book ratio of 1.35 for the companies in the MAC Solar Index is far below the 3.52 ratio for the S&P 500. The price-to-sales ratio of 1.11 for the MAC Solar Index is far below the 2.29 ratio for the S&P 500.

Solar stocks rally on expanding solar growth

Solar stocks in 2019 have rallied sharply due to (1) underlying support from the sharp rally seen in the overall global stock markets during 2019, (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 outside China in 2019 and beyond.

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 could bring more projects to market since solar has become even more economical versus alternatives such as nuclear, coal, natural gas, and wind.

The sharp drop in solar pricing in 2018 made new large-scale solar projects cheaper than fossil-fuel and nuclear plants in many cases, leading to very strong new solar demand from utilities and corporations. There is now a big pipeline of global solar projects, supporting expectations for a strong year for solar installs in 2019 and 2020. Bloomberg New Energy Finance (BNEF) is forecasting

that global solar installs in 2019 will grow by +12% to 121 GW from 108 GW in 2018.

In China, solar installs in the first nine months of 2019 were disappointing at only 16 GW because the government was slow to announce the details of its new policies for subsidized and unsubsidized solar. However, Chinese-based solar companies responded by exporting some 70% of their output to other areas of the world that are showing very strong solar growth.

In the U.S., solar growth is expected to be particularly 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's electricity cost falls 7% and beats fossil fuels and nuclear by even larger amounts

The levelized cost of electricity (LCOE) for newly-built U.S. utility-scale solar PV plants in late 2019 fell by -7% yr/yr to a midpoint of $40 per MWh ($36-44 range) for crystalline PV on an unsubsidized basis, adding to 2018's -13% decline, according to Lazard in the latest annual edition of its comprehensive "Levelized Cost of Energy Analysis-Version 13.0" released in November 2019. The LCOE for thin-film utility-scale solar fell by a similar -7.5% yr/yr to an even lower mid-point price of $37 per MWh ($32-42 range).

The cost of residential and corporate solar PV systems also fell. The Lazard report found that the unsubsidized mid-point LCOEs fell by -3% yr/yr for Community Solar to $106/MWh ($64-148 range), -9% yr/yr for Roof-Top Commercial and Industrial to $114.5/MWh ($75-154), and -8% yr/yr for Rooftop Residential to $196.5/MWh ($151-242).

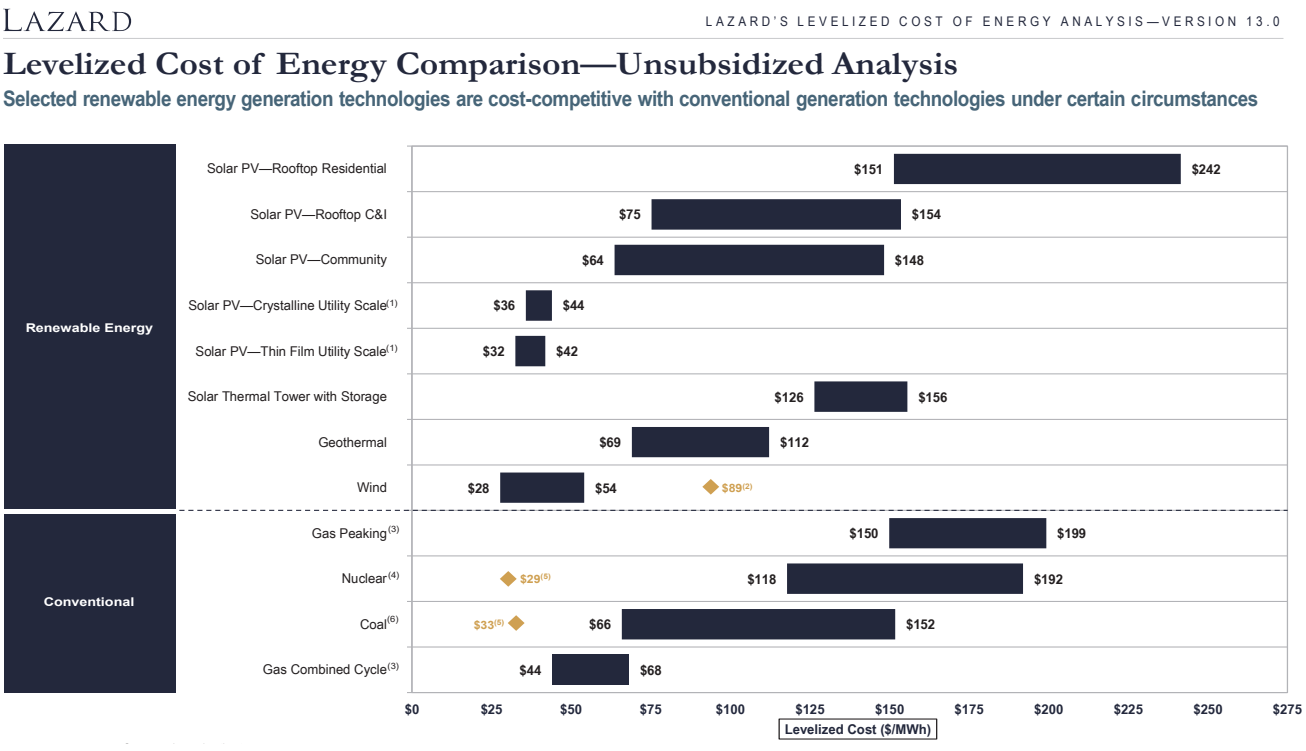
The Lazard report found that the mid-point cost for utility-scale crystalline solar PV of $40/MWh is now 63% cheaper than the $109/MWh mid-point cost for newly-built coal plants, 74% cheaper than the $155/MWh mid-point cost for nuclear plants, and 77% cheaper than the $174.5/MWh mid-point cost for gas-peaking plants.

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 midpoint cost of $40/MWh (range $36-44/MWh) is now 29% cheaper than the mid-point cost of $56/MWh (range $44-68) for natural gas plants. That illustrates that the cost of utility-scale solar now beats the cost for building a natural gas plant in many cases.

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 $29/MWh and $33/MWh for coal, which is below the $40/MWh mid-point cost for building a brand-new utility-scale solar plant.

That 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 and wind plants. However, as coal and nuclear plants reach the end of their useful lives, 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 in supporting solar as a 24/7 base-load electricity resource.

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 lives and must be retired. In addition, increased pollution and carbon constraints mean that the marginal cost of operating coal plants will steadily rise in coming years, thus encouraging utilities to phase out their aging coal plants sooner rather than later.

It is also worth noting that the marginal cost of running an existing solar plant is negligible compared with the cost of running coal, gas, or nuclear plants since the sun is free. In addition, the operating costs of a solar plant are very predictable and present much less cost risk for a utility than a coal or natural gas plant where the future cost of the fuel is not known.

Solar has become cheaper than new fossil fuel plants, not just in the U.S., but also globally. BNEF reports that for two-thirds of the world's population, it is already cheaper to get new power from solar or wind than from new fossil fuel plants.

Corporations show strong demand for solar

Corporations are becoming increasingly important buyers of solar power. Corporations can buy solar power by (1) buying solar panels and installing them onsite, or (2) buying solar power through Power Purchase Agreements (PPAs). With a PPA, a corporation enters into a contract with a solar facility owner to pay a certain price per megawatt-hour of electricity that the corporation uses over a long period of time such as 10 years or more.

Corporations have entered into 15.5 GW of clean energy PPAs so far in 2019 across the world, which is more than double the year-earlier figure of 6.2 GW, according to BNEF. Corporate PPAs are the most popular in the Americas, which account for 82% of this year's corporate PPAs, according to BNEF. However, corporate PPAs are also starting to boom in Europe, reaching a record high of 200 MW so far this year.

There are now more than 200 global companies that have joined the RE100 initiative and have agreed to move towards getting 100% of their electricity from renewable sources. These RE100 corporations already effectively get 39% of their electricity from clean energy, mostly by buying renewable energy credits.

However, the RE100 companies need to buy 189 terawatt-hours of clean electricity through 2030 to meet their 100% renewable energy goals, according to BNEF. That represents a massive $97 billion worth of clean energy purchases through 2030.

Regarding the breakdown of corporate clean energy purchases, Wood Mackenzie reports that corporate solar purchases in 2019 of 1.3 GW are expected to lag wind purchases of 3.9 GW. However, Wood Mackenzie expects solar to quickly overtake wind in coming years with annual purchases of 6.6-12.5 GW of solar purchases by 2030, far more than wind purchases of less than 2 GW.

The Solar Energy Industry Association (SEIA) in July released a comprehensive report on corporate solar entitled "Solar Means Business." The SEIA report found that there is currently 7 GW of corporate solar power installed in the U.S. across 35,000 installations, which is 23 times what it was a decade ago.

The report found that the biggest corporate users of solar power are Apple, Amazon, Target, Walmart, Switch (data centers), and Google. Other notable big corporate solar users include IKEA, Macys, Kohls, Costco, Starbucks, Paypal, Home Depot, and many others.

UN calls climate outlook "bleak" as global emission cuts fall far short

The UN Environmental Program (UNEP) in its annual Emissions Gap Report said that the world is falling far behind in the goals for limiting global warming.

The report said, "The summary findings are bleak. Countries collectively failed to stop the growth in global GHG emissions, meaning that deeper and faster cuts are now required."

The world has already warmed by 1 degree Celsius (1.8 degrees Fahrenheit) from pre-industrial levels. The goal is to limit the warming to well below 2.0 degrees Celsius (3.6 degrees Fahrenheit) and preferably below 1.5 degrees Celsius. However, the world is currently on track for warming of 3.9 degrees Celsius (7 degrees Fahrenheit) by the end of this century, which would result in catastrophic damage, according to UNEP.

The current pledges in the Paris agreement for emission cuts are not enough to keep warming below 2 degrees Celsius. To make matters worse, most countries aren't even meeting their current Paris pledges. The Trump administration is in the process of withdrawing the U.S. altogether from the Paris climate agreement and reneging on America's previous emission-cut pledge. The UNEP report says that the Paris pledges need to be tripled and then met in order to prevent global warming from causing catastrophic damage.

The report said that "Incremental changes will not be enough and there is a need for rapid and transformational action." The report says those changes will require the investment of at least $1.6 trillion annually in energy-sector investment through 2050, for a total of $48 trillion. That illustrates the massive opportunity for solar power to provide one of the most economical solutions for global warming.

SOLAR PV GROWTH OUTLOOK

Global solar growth is expected to strengthen in 2019 after the obstacles seen in 2018. Bloomberg New Energy Finance (BNEF) is forecasting that solar installs in 2019 will grow by +12% to 121 GW from 108 GW in 2018. Meanwhile, IHS Markit is forecasting that world solar installs in 2019 will be stronger at 129 GW, up by 25% from their 2018 install figure of 103 GW. See page 9 for solar growth charts.

In 2018, world solar growth rose by +9% to 108 GW from 99 GW in 2017, according to BNEF. Solar growth in 2018 grew by only +9% because it 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%). 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 pricing boosts the 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 are 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 -84% since 2010 and by an average -13% per year over the last five years, according to Lazard.

New utility-scale solar plants are now cheaper to build (even without subsidies) than any other conventional power source. Lazard reports that the mid-point cost for building a new U.S. utility-scale crystalline solar PV plant of $40/MWh is now 29% cheaper than the $56 mid-point cost of a natural gas plant, 63% cheaper than the $109 mid-point cost of a coal plant, 74% cheaper than the $155 mid-point cost for a nuclear plant, and 77% cheaper than the $174.5 mid-point cost for a gas-peaking plant (Lazard LCOE 13.0, November 2019).

Looking ahead, BNEF expects a further -71% drop in the cost of solar PV plants by 2050, which would make solar dramatically cheaper than any other electricity source including coal, nuclear, natural gas, or wind.

Chinese solar installs downshift as market adjusts to government's subsidy phase-out

China's solar growth in 2019 has so far been very weak as the market adjusts to the Chinese government's policy of phasing out subsidies by 2022. China installed only 16 GW of solar in the first nine months of 2019, which represents a sharp -50% yr/yr decline. Chinese solar installs are expected to surge in Q4 as delayed projects come online. However, Chinese solar installs in 2019 will strain to reach even 30 GW, which would be well below most industry forecasts earlier in the year of 40-45 GW and down from 2018's install rate of 44 GW.

Due to the weak solar-install level seen so far in 2019, BNEF in November sharply cut its forecast for Chinese 2019 solar installs to 28 GW from its previous forecast of 39 GW, which would be a -37% yr/yr decline.

Chinese solar installs in 2018 already fell by -16% to 44 GW from the record high of 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 sharp cut to most of its solar subsidies, with utility-scale solar capped at 40 GW and roof-top distributed generation (DG) capped at 10 GW in 2018. China's subsidy phase-out plan is referred to in the industry as the "China-531" order after the date of the announcement.

The slow roll-out of China's new solar programs in late 2018 and the first half of 2019 caused China's solar installs to be weak in the first nine months of 2019. The government did not approve the first batch of unsubsidized solar projects totaling 14.8 GW until May 2019 and the 23 GW of subsidized projects until July 2019. That meant that many solar projects were delayed and that a significant number of projects will not be finished until late 2019 and early 2020.

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. China can now afford to move towards unsubsidized solar since the cost of solar has dropped so dramatically in recent years that it has become competitive with other sources of electricity generation such as coal without the need for subsidies.

The move away from subsidies should be a long-term positive for the Chinese solar industry since the industry should be able to grow in a more predictable manner with 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, thus 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.

SOLAR PV GROWTH OUTLOOK (CONTINUED)

The Chinese government will still subsidize a significant amount of solar in 2019 and 2020 before subsidies are fully phased out. China's Ministry of Finance said in November 2019 that its renewable power subsidy in 2020 will be a hefty 5.67 billion yuan ($806 million), down from 8.1 billion yuan in 2019. Solar projects in 2020 will receive 2.63 billion yuan of that subsidy, covering distributed solar power and poverty-alleviation projects.

For unsubsidized solar, China's government is providing 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 preferential measures for 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.

U.S. solar growth is expected to show solid growth following recent volatility

U.S. solar growth is expected to be strong 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) before it progressively steps down to 10% by 2022 and beyond for all solar projects except 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 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 U.S. 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 then ended up extending the ITC by 5 years.

The initial Section 201 import tariff of 30% in 2018 already 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 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.

The Trump administration in June 2019 surprised the solar industry by exempting bifacial (two-sided) solar panels from the Section 201 tariff, which resulted in a surge in the imports of those panels during summer 2019. However, the Trump administration then reversed its decision and by November 2019 had nearly completed the process of re-imposing the tariff on bifacial solar panels.

SOLAR PV GROWTH OUTLOOK (CONTINUED)

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 indicated 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.

On the tariff front, the U.S. solar sector is also dealing with some disruptions in the solar inverter market. 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 impose 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.

In another tariff development, the Trump administration on September 1, 2019, imposed a 15% tariff on about $110 billion of Chinese goods that included Chinese lithium-ion batteries. Before the tariff, the U.S. imported 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. That means that the U.S. tariff on Chinese batteries will not have much effect on the U.S. solar-plus-storage market.

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 needs 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's solar 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 started out at 25% for the first year (30-Jul-2018 to 29-Jul-2019) but then stepped 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 can 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.

SOLAR PV GROWTH OUTLOOK (CONTINUED)

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's 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, -8% in 2017, and -8% in 2018 to 6.8 GW, leaving solar installs well below 2015's peak of 11.2 GW, 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.

Vietnam surges to solar lead in Southeast Asia

Vietnam has taken over the solar lead from Thailand in Southeast Asia with a surge to 4 GW of solar power commissioned in the first half of 2019. That is remarkable growth from solar installs of just 168 MW in 2018. Wood Mackenzie is forecasting that Vietnam in 2019 will install 5.5 GW of solar, up from 134 MW in 2018, and accounting for almost half of the installs in Southeast Asia.

The surge in Vietnam's solar in the first half of 2019 was due to developers trying to take advantage of a feed-in tariff of $93.50 MWh that lasted for a 2-year period through June 2019. Solar growth is expected to slow as Vietnam cuts the feed-in tariff for the next 2-year period.

European solar growth is accelerating sharply

European solar growth has accelerated sharply since the EU in late 2018 did away with the prior minimum-price scheme. Solar is also seeing strong growth as subsidy-free solar spreads as far north as the UK. In addition, Europe is taking its climate goals seriously and is mandating increasing amounts of solar power to meet its targets for cutting emissions.

BNEF is expecting very strong solar growth in Europe of +112% to 14.7 GW in 2019. That would follow strong growth of +38% to 6.9 GW in 2018.

In 2018, Germany continued to be the largest solar player in Europe by far with 2.9 GW of installs, up by +77% from 1.7 GW in 2017 (BNEF). 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.

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 unsuccessfully to protect local European solar manufacturers from Chinese competition. The MIP scheme succeeded only in raising the cost of solar modules for European solar installers and caused several years of very slow solar growth in Europe.

The end of the MIP scheme, combined with the sharp drop in solar module prices that resulted from the China-531 order in 2018, allowed solar to reach grid-parity in a growing portion of Europe. As of October 2019, BNEF was tracking 40 subsidy-free PV projects in Europe, totaling 5.5 GW. BNEF says most of those subsidy-free PV projects have signed power-purchased agreements (PPAs) with electricity traders or utilities, although 1.3 GW of those PPAs were with corporations.

European solar growth is 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.

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

SOLAR PV GROWTH OUTLOOK (CONTINUED)

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 its 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 210 MW renewable power auction in April 2019 and all of the 200 MW renewable power auction in October 2019, leaving wind with no successful bids.

The average winning solar bid in the October 2019 auction was an impressively-low 54.0 euros ($60.0) per MWh in the October 2019 auction, which was 13% below the winning bid in a wind-only auction in October.

In France, an auction of 200 MW of mixed renewable capacity in November 2018 was also won by all solar projects and no wind with an average solar price of 54.9 euros ($61.5) per MWh.

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 Latin 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

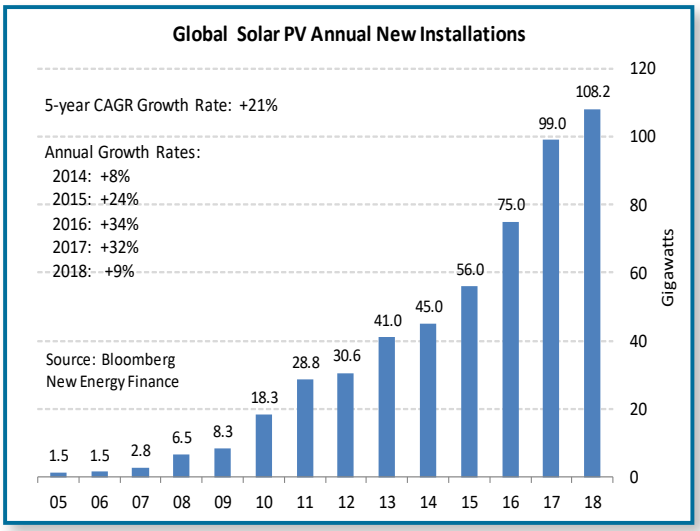
New global solar PV installations in 2018 grew by +9% yr/yr to a record 108 gigawatts (GW), according to Bloomberg New Energy Finance (BNEF). The 2018 growth rate of +9% followed growth rates of +32% in 2017 and +34% in 2016. Global solar PV installations have grown at a compounded annual rate of +21%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

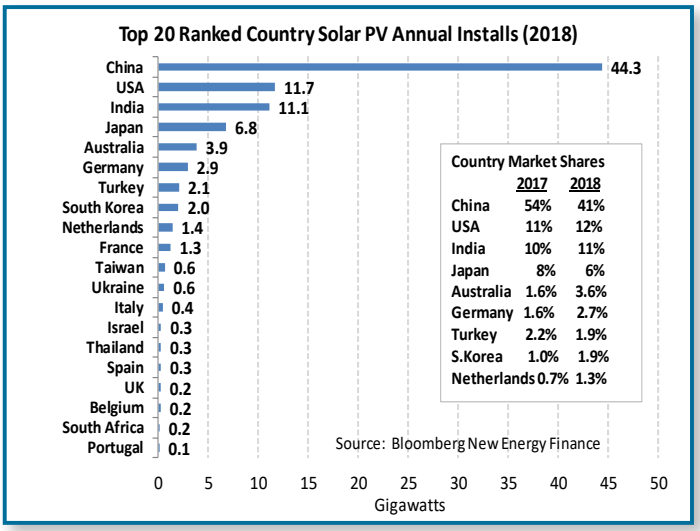
In 2018, China led the world for annual solar PV installs for the fifth straight year with 44 GW of installs, down by -16% from the record high of 53 GW in 2017, according to BNEF. The U.S. remained in second place in 2018 with 11.7 GW of installs, up by +6% yr/yr from 11.0 GW in 2017. India remained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

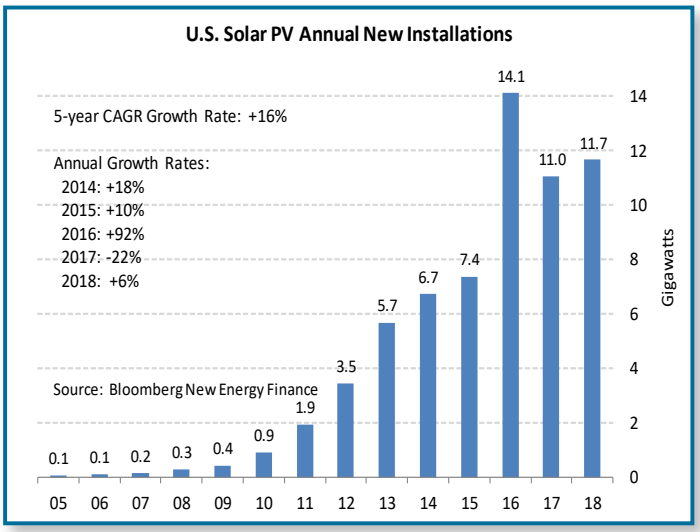
There were ten countries in 2018 with installs above 1 GW versus only seven such countries in 2016 and 2017, illustrating the geographical spread of solar. It was also notable that China's share of total global installs fell to 41% in 2018 from a hefty 54% in 2017, illustrating the more balanced nature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

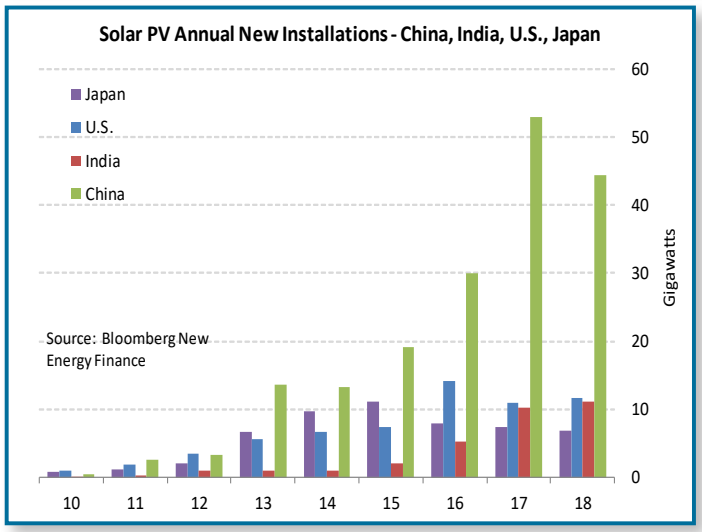
Solar growth in Europe in 2018 was generally strong with Germany up +77% yr/yr to 2.9 GW, Netherlands up +101% to 1.4 GW, France up +41% yr/yr to 1.3 GW, Italy up +6% at 435 MW, and Spain up +94% to 262 MW (BNEF). However, UK solar in 2018 fell sharply by -73% to 243 MW.

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

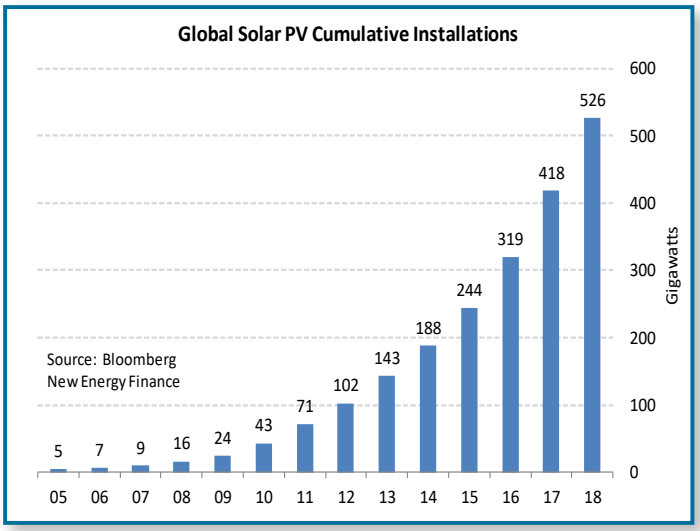
The amount of cumulative PV electricity generation capacity across the world grew sharply by +26% yr/yr to 526 GW in 2018, according to Bloomberg New Energy Finance (BNEF). In the last five years, global cumulative solar PV electricity generation capacity increased by more than 3-fold from 143 GW in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

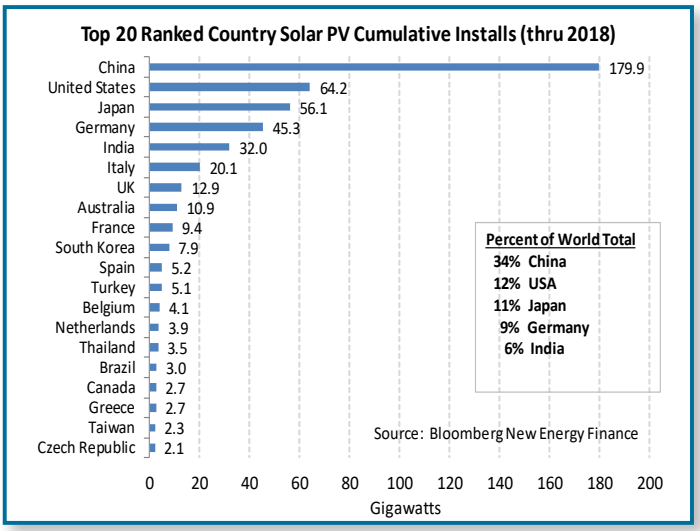
China continued to be the world's leader for cumulative solar capacity at 180 GW, according to BNEF. China at the end of 2018 accounted for 34% of the world's solar PV capacity. In the past five years, China's cumulative installed solar capacity soared 9-fold from 20 GW in 2013 to the 2018 level of 180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

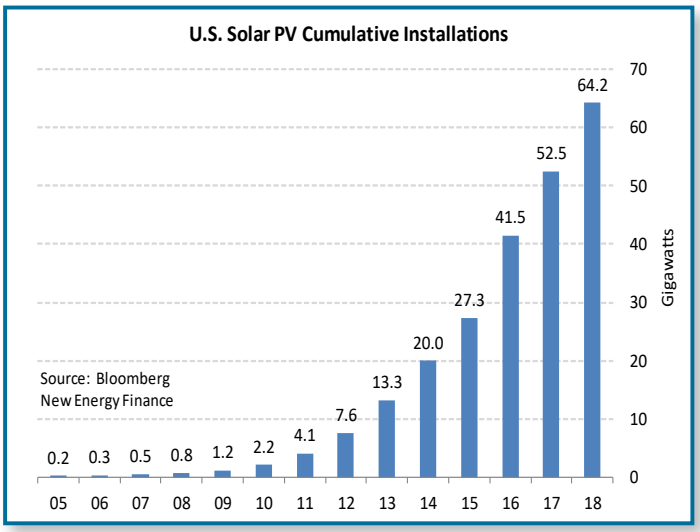
The U.S. in 2018 remained in second place in cumulative solar installs. U.S. solar electricity capacity in 2018 rose by +22% to 64 GW, representing 12.2% of world capacity. U.S. cumulative solar electricity capacity over the past five years rose by more than 4-fold to 64 GW from 13 GW in 2013 and showed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

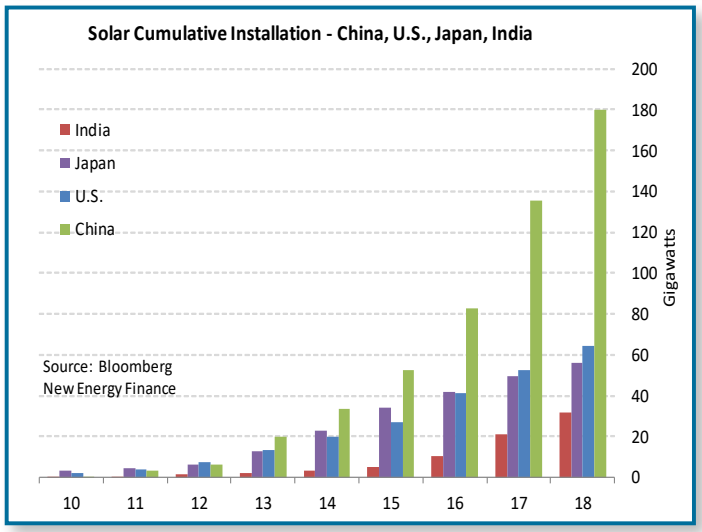
Japan remained in third place for the fifth straight year. Japan's cumulative solar capacity in 2018 rose by +14% to 56 GW, representing 10.7% of world capacity. Japan's cumulative solar capacity in the past 5 years has risen by more than 4-fold to 56 GW from 13 GW in 2013, representing a 5-year compounded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









PRICING - SOLAR MODULES, CELLS, AND POLYSILICON

World prices for solar cells and modules continue to edge lower and post new record lows.

The price of multicrystalline solar cells in November 2019 fell to new record low of 20 cents per watt and have plunged by a total of -88% since mid-2011, according to Bloomberg New Energy Finance (BNEF).

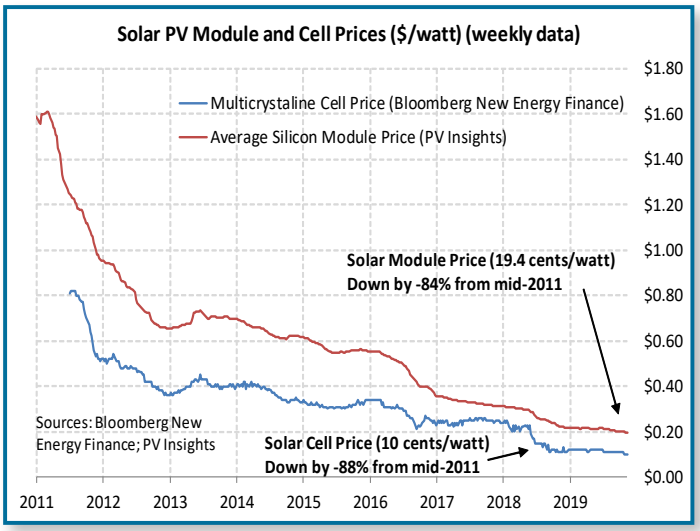
The price of silicon solar modules in November 2019 fell to a new record low of 19.4 cents per watt and have plunged by a total of -84% since mid-2011, according to PV Insights.

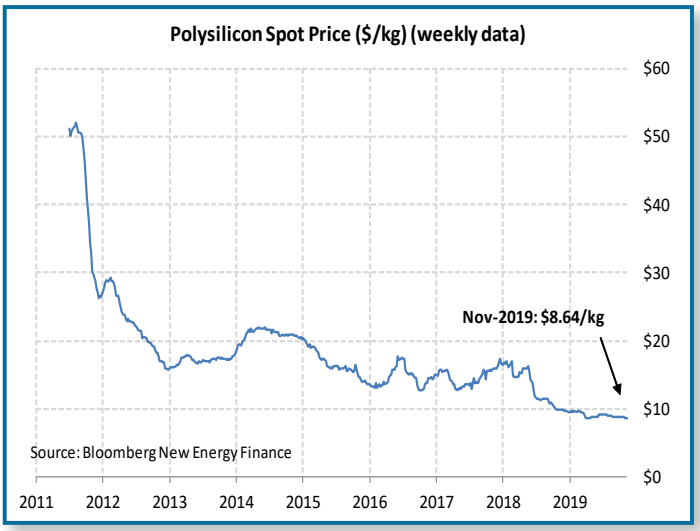
The price of thin-film modules in November 2019 fell to a new record low of 23.7 cents per watt and have plunged by a total of -74% since mid-2011, according to PV Insights.

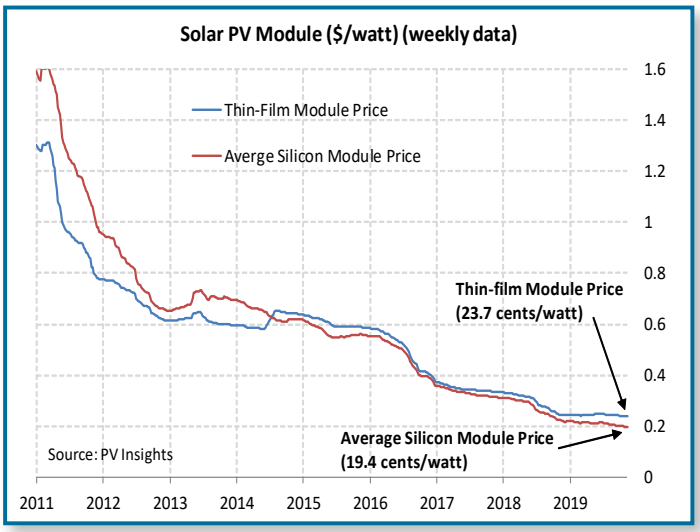
Spot polysilicon prices fell to a record low of $8.57 per kg in April 2019 and are currently slightly above that level at $8.64, according to BNEF. Polysilicon prices have plunged by a total of -83% since mid-2011. The decline in polysilicon prices is a key factor in allowing solar cell and solar module prices to decline since polysilicon is the main raw material for most solar cells.

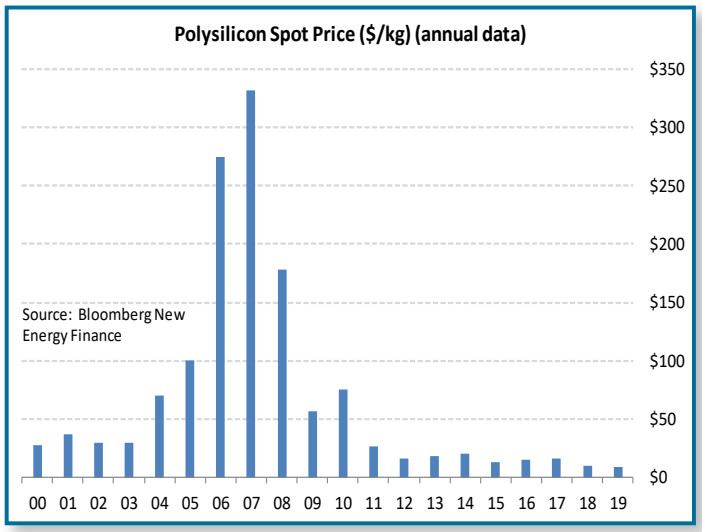
Solar prices have drifted mildly lower during 2019 in line with the natural decline in solar pricing that results from lower production costs that are in turn due to (1) technology advances, and (2) economies of scale in manufacturing.

Solar pricing in 2019 has stabilized following previous sharp declines. In 2018, for example, solar pricing fell sharply due to the oversupply situation that resulted from the Chinese government's sharp cutback of subsidies with its May 31, 2018 order (China-531). In the second half of 2016, solar prices fell sharply because of a module oversupply situation that followed solar install spikes seen in China and the U.S. caused by developers trying to beat respective subsidy-reduction deadlines. Solar pricing is now becoming less volatile as solar subsidies are phased out, thus reducing the risk of previous subsidy-related boom-bust cycles.









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.