

SOLAR SECTOR UPDATE

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

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

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MAC Global Solar Energy Index (SUNIDX)



SOLAR INDEX PERFORMANCE

The MAC Global Solar Energy Stock Index, the tracking index for the Invesco Solar ETF (NYSE ARCA: TAN), has rallied sharply in the past year and posted a new 12-year high in January 2021. The Index has since settled back and is down by -15.0% on a year-to-date basis, giving back some of the extraordinary +235% annual gain seen in 2020.

The MAC Solar Index earlier took a sharp hit, along with the rest of the stock market in early 2020, on the Covid pandemic's emergence. However, the Index then staged a rally of more than 5-fold on strength in the overall stock market and on polls suggesting that Joe Biden would win the November 2020 presidential election. The MAC Index then reached its highs in January after Joe Biden became president and Democrats won control of both the House and Senate.

Bullish longer-term factors for solar stocks include (1) expectations for a global dash to reduce carbon emissions now that the U.S. has reclaimed its leadership role in the global Paris climate effort, (2) the strong global solar demand picture that has resulted from the fact that solar has now reached unsubsidized grid parity in more than two-thirds of the world, (3) the stabilization of solar cell

and module prices in 2019-20 that helped the profitability of solar manufacturers, (4) the pairing of solar with large-scale battery systems to provide a 24/7 electricity solution, (5) broadening solar growth in India, Turkey, Latin America, Middle East, and Southeast Asia, and (6) strong demand for renewable energy as countries seek to meet their carbon-reduction targets under the Paris COP21 global climate agreement.

Bearish factors for solar stocks include (1) the Covid pandemic that continues to hamper solar planning and installations, (2) the transition in China to unsubsidized solar, (3) 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 (4) temporary obstacles to India's solar growth from the pandemic and the government's solar tariffs.

Solar stocks remain generally strong on long-term growth prospects and renewed policy support

Solar stocks since spring 2020 have rallied sharply due to (1) the overall recovery in global stocks seen since the pandemic-induced dip in spring 2020, (2) the realization that solar is emerging as a key solution to climate change as it becomes the cheapest source of new electricity generation and is paired with battery storage for 24/7 electricity, (3) the Democratic sweep of Washington in the November 2020 election and expectations for a strong solar push from Washington, (4) the extension of the solar ITC by two years in December 2020, and (5) a big European renewable energy push to stimulate the pandemic-ravaged economy and meet its Paris climate goals.

Global solar installs in 2020 grew at a very strong rate of +21% despite the pandemic, according to Bloomberg New Energy Finance (BNEF). Moreover, global solar growth is expected to have an even bigger year in 2021 with growth of +29%, according to forecasts by BNEF.

Solar growth is currently running strong in China, the U.S., Europe, and many other countries around the world. China's solar installs in 2021 will grow by +34%, U.S. solar installs will grow by +12%, and EU installs will grow by +19%, according to BNEF forecasts. India's solar installs in 2021 are expected to soar by +183% on a recovery from 2020's slump of -63%.

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SOLAR PV GROWTH OUTLOOK

Global solar growth is expected to show another very strong year in 2021 despite ongoing disruptions from the Covid pandemic. Bloomberg New Energy Finance (BNEF) is forecasting that solar installs in 2021 will grow by +29% to 185 GW from 143 GW in 2020.

In 2020, world solar growth soared by +21% to 143 GW, accelerating from the +9% growth rates seen in both 2018 and 2019, according to BNEF. Solar growth in 2018 and 2019 was hindered by a temporary pull-back in Chinese solar installs and two years of global retrenchment after two very strong global solar growth years in 2016 (+34%) and 2017 (+32%). Over the past five years (2015-20), global solar has grown by a very strong compounded annual growth rate of +21%.

Solar growth soared in 2020 despite the pandemic, which slowed planning, construction, and supply-chain deliveries. Solar is being installed at a torrid clip across the globe due to its low cost and attractiveness as a long-term solution for a sustainable energy future. Solar's low cost means that it is now on a strong long-term growth path without the need for government subsidies.

Solar will account for 28% of all electricity capacity additions, and there will be a massive \$4.2 trillion of spending on solar through 2050, according to BNEF's 2020 New Energy Outlook. BNEF forecasts that solar PV will account for 38% of world electricity capacity by 2050, up sharply from the 2019 level of 11%.

Solar will easily be the largest source of electricity generation in 2050 at 38%, far outpacing wind at 20% and gas at 15%. BNEF expects coal to fall to 7% of electricity generation by 2050 from 28% in 2019, and for nuclear to drop to 2% in 2050 from 5% in 2019.

"I see solar becoming the king of the world's electricity markets, Fatih Birol, executive director of the International Energy Agency (IEA), said upon the release of the IEA's flagship World Energy Outlook report. In that report, the IEA forecasts that solar will easily become the largest source of electricity generation by 2040. The report goes on to say:

"Solar PV becomes the new king of electricity supply and looks set for massive expansion. From 2020 to 2030, solar PV grows by an average of 13% per year, meeting almost one-third of electricity demand growth over that period. Global solar PV deployment exceeds pre-crisis levels by 2021 and sets new records each year after 2022 thanks to widely available resources, declining costs and policy support in over 130 countries."

Demand for solar should surge in the 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 -85% since 2010 and by an average -11% per year over the last five years, according to Lazard (see p. 9).

China's transition to subsidy-free solar is progressing well

There is strong optimism about the Chinese solar market as it shakes off the Covid pandemic and shifts toward a subsidy-free market in the coming years.

The markets are also optimistic about the Chinese government's intent to rely heavily on solar to meet increasingly aggressive climate targets. In September 2020, China's President Xi surprised the world by announcing at the UN General Assembly that China intends to be carbon-neutral by 2060, which is the first time China has set such a target.

In December 2020, President Xi then announced a more specific target of 1,200 GW of solar, wind, and biomass capacity by 2030, which is nearly triple the current capacity of 450 GW. The Chinese government also proposed a new clean power mandate that would require grid operators, power retailers, and large consumers to source 25.9% of their output from solar, wind, or biomass by 2030. BNEF estimates that meeting that mandate would require 1,580 GW of cumulative capacity by 2030, or a third higher than President Xi's earlier goal of 1,200 GW.

The Chinese government in March 2021 then announced a draft of the 14th Five-year Plan for 2021-2025. That plan reiterated the targets for carbon emissions to peak before 2030 and achieving carbon-neutrality by 2060. The plan also contained some details on how those targets will be met. One of the key targets in the plan was a goal of generating 20% of its electricity from non-fossil fuel sources by 2025, which is just a few years away. The 20% target was up from the previous target of 15.9%.

Turning to solar growth rates, Chinese solar installs in 2020 soared by +57% to 52.1 GW from 33.1 GW in 2019. The 2020 install level of 52 GW was just slightly below the record high of 53.0 GW posted in 2017.

Solar installs were undercut in early 2020 by the Covid pandemic but finished the year on a very strong note as developers sought to beat the expiration of some subsidies at the end of 2020.

BNEF is forecasting that Chinese solar installs in 2021 will have another huge year with growth of +35% to 70.3 GW. Strength in 2021 is expected to be driven in part by the completion of projects that were started in 2020 to qualify for subsidies.

Chinese solar installs are expected to remain strong even though the Chinese government is transitioning to a solar market without national subsidies. Developers showed strong interest in subsidy-free solar projects in 2020 since they can still earn attractive internal rates of return. The Chinese government has also added benefits to subsidy-free projects, such as a guaranteed price for solar electricity output and priority on the grid. Solar projects can still qualify for subsidies at the local level.

SOLAR PV GROWTH OUTLOOK (CONTINUED)

The move away from national subsidies should be a long-term positive factor for the Chinese solar industry since the industry should be able to grow in a more predictable manner with more stable profit margins, as opposed to the boom-bust days of the past that were caused by erratic government subsidy policies. Without subsidy distortions, 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 current trend should accelerate whereby the solar industry is dominated by large players with the best technology and the lowest production costs.

In recent years, the Chinese solar market has been buffeted by erratic subsidy policies that previously caused upheaval in the industry. For example, Chinese solar installs in 2017 soared by 76% to a record high of 53.0 GW as developers took advantage of very generous government subsidies.

However, in response to that 2017 install surge, the Chinese government, on May 31, 2018, announced a sharp cut in 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 was referred to in the industry as the "China-531" order after the date of the announcement.

The government was forced into its China-531 action partly by the big backlog of unpaid subsidies that reached \$23 billion by the end of 2018. The China-531 curtailment of subsidies caused a sharp drop in Chinese solar installs by -17% to 44.3 GW in 2018 and -25% to 33.1 GW in 2019.

U.S. solar is seeing blockbuster growth

U.S. solar growth is seeing blockbuster growth due to its low cost and strong policy support. U.S. solar installs in 2020 soared by +64% to 18.9 GW, adding to 2019's strong +15% growth rate to 11.5 GW. BNEF is forecasting another strong year for U.S. solar in 2021 with growth of +12% to 21.1 GW.

Solar accounted for a hefty 43% of U.S. electricity installs in 2020, which was a record high and up from 40% in 2019, according to Wood Mackenzie. Solar remained first among all the electricity generation technologies for the second straight year, beating the 38% share for wind and 18% share for natural gas. The share of natural gas electricity additions fell sharply to 18% in 2020 from 32% in 2019 and 57% in 2018 as solar and wind took the lion's share of new installs and shoved aside natural gas.

Solar showed very strong growth in 2020 despite the pandemic, which turned out to have only a minor impact on the overall install rates. The residential sector was negatively impacted by the pandemic in Q2-2020 but then came roaring back in the second half of the year and still showed strong yearly growth of +11% to 3.1 GW.

Solar installs in the non-residential sector (commercial, government, nonprofit, and community solar) showed a -4% decline in 2020 to 2 GW, according to Wood Mackenzie. Non-residential installs were undercut by the pandemic, which slowed development timelines and delayed project interconnections.

By contrast, U.S. utility solar installs in 2020 soared by +60% to a new record of just under 14 GW, according to Wood Mackenzie. Moreover, Wood Mackenzie expects strong growth to continue into 2021 due to a massive utility-solar pipeline of 69 GW. The firm expects utility solar to show continued strong growth due to "the expansion of state-level renewable energy targets, utilities' self-enforced carbon reduction plans, a renewed focus on clean energy deployment at the federal level, and large corporate off-takers looking to meet net-zero carbon emissions goals."

Solar installs in 2020 also showed strength as developers sought to take advantage of the 26% solar investment tax credit (ITC) in 2020 before it was to step down to 22% in 2021 and 10% in 2022 for utility PV projects, non-residential, and third-party-owned residential solar projects (but to zero for direct-owned residential projects).

However, the solar industry received a pleasant surprise in December 2020 when Congress extended the solar ITC for another two years as part of the combined passage of the \$900 billion pandemic aid bill and the \$1.4 trillion omnibus spending bill. The 2-year extension of the ITC caused Wood Mackenzie to increase its U.S. solar install figure by a total of +17% for its 2021-25 forecast.

The ITC is now set at 26% for 2021 and 2022. The ITC will then fall to 22% in 2023 and then in 2024 to 10% indefinitely for large-scale solar projects and to zero for small-scale solar projects.

The U.S. solar industry received even better news in March 2021 when the Biden administration announced that its \$2.25 trillion infrastructure plan includes a proposal for a 10-year extension of the ITC and a hike in the ITC rate to 30% from the current 26%. Also, the ITC proposal would have a "direct pay" provision, which would allow tax credits to be converted into direct payments from the federal government, rather than as an offset by investors against tax liabilities, which a shortage of tax equity can hinder. The solar industry is waiting to see whether Congress will pass the 10-year solar ITC as proposed by the Biden administration.

The Biden infrastructure proposal also contains \$100 billion for the electricity sector and energy programs over the next eight years. The program included tax credits for storage and for grid modernization that would benefit the solar industry. The program also designated \$180 billion for climate-related research, pilot projects, and other R&D efforts in advanced technologies.

SOLAR PV GROWTH OUTLOOK (CONTINUED)

The Biden infrastructure plan also contains a Clean Energy Standard (CES) proposal that would require a 100% zero-carbon U.S. electricity sector by 2035. The federal Clean Energy Standard would be similar to the state-level CES standards that already exist in thirty states, which are used to pressure utilities to move towards clean electricity and reduce their emissions.

However, the Biden CES proposal contained few details, and Congress will need to design the actual legislation. There is unlikely to be bipartisan support for the CES proposal, which means the CES will have to bypass a Senate Republican filibuster either by (1) Senate Democrats doing away with the filibuster altogether, or (2) designing the CES so that it qualifies for passage under the Senate's budget reconciliation process, which requires only a majority vote in the Senate. There are questions about whether a federal CES can be designed to fit within the constraints of the budget reconciliation process, which requires measures to materially affect the budget or national debt.

In any case, the U.S. solar energy industry received a big boost of optimism when Joe Biden was elected President in the November 2020 election, and Democrats were able to take control of the Senate as well as the House. Democrats will now be able to pass any legislation they wish that fits under the budget reconciliation process, which would bypass a Senate Republican filibuster. However, bipartisan support would still be necessary for legislation that doesn't affect the budget and doesn't qualify for the budget reconciliation process.

President Biden, on his first day in office, announced that the U.S. would rejoin the international Paris Climate Accord. That confirmed that the U.S. would resume its global leadership position in trying to meet the Paris Climate Accord's goal of keeping global warming to less than 2 degrees Celsius above the pre-industrial level, and preferably below 1.5 degrees Celsius. President Biden also pledged to reach a 100% carbon-free electricity sector by 2035 and to reach net-zero greenhouse gas emissions by 2050.

Mr. Biden named former Senator John Kerry as his Presidential climate envoy. Mr. Kerry said that meeting the current Paris emissions goals is not enough and that tighter restrictions are needed. Mr. Kerry said that even if every country delivered on its current commitments, there would still be a warming of planet Earth of about 3.7 degrees Celsius, which he said would be "Just catastrophic."

The Biden administration is expected to announce soon a more stringent emissions target than the commitment made by President Obama of a 26-28% cut in greenhouse gas emissions below 2005 levels by 2025. That announcement of a new "Nationally Determined Contribution" is expected ahead of President Biden's invitation to 40 world leaders for the "Leaders Summit on Climate" that he will host on April 22-23. The next United National Climate Change Conference (COP26) will be held this November in Glasgow.

The markets are waiting to see how the Biden administration will handle the tariffs on the solar industry that were previously imposed by the Trump administration. There is concern that Mr. Biden will take a continued aggressive approach to China on solar tariffs. Indeed, the Biden administration in March argued in court that the Trump Administration's reimposition of tariffs on bifacial solar panels was legal and should remain in effect.

The U.S. solar market in recent years has been negatively impacted by solar tariffs imposed by the Trump administration. Mr. Trump, in January 2018, announced a Section 201 tariff of 30% on imported solar cells and modules, which hurt solar install growth because of the higher price of solar panels for U.S. solar projects. The markets are waiting to see if the Biden administration might raise or extend that tariff.

The initial Section 201 import tariff of 30% for 2018 already stepped down to 25% as of February 2019, 20% as of February 2020, and 15% as of February 2021. The tariff is set to drop to zero in February 2022, when 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 imports of those panels during summer 2019. The Trump administration then reversed its decision but had difficulty reimposing the tariff due to procedural requirements.

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) 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.

However, the inverter tariff 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 makes 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.

On another tariff issue, 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

SOLAR PV GROWTH OUTLOOK (CONTINUED)

China, although most of those batteries were for end-markets other than grid storage.

China supplies less than 5% of the batteries used in large-scale U.S. energy storage products, according to BNEF, which means that the U.S. tariff on Chinese batteries did not have much impact on the U.S. solar-plus-storage market.

U.S. solar growth has been very volatile in recent years, mainly because of changes by the U.S. government in tax credits and tariffs. In 2016, solar growth spiked higher by +92% to beat the scheduled expiration of the investment tax credit (ITC) at the end of 2016, although Congress in December 2015 then extended the ITC by 5 years.

However, U.S. solar installs then fell by -23% in 2017 and by -2% in 2018 on a let-down after the 2016 spike and on the solar tariffs imposed by the Trump Administration in January 2018.

In 2019, U.S. solar growth showed a more stable growth rate of +8.0% after the volatility seen in the previous several years. Solar growth in 2020 then soared by +64% on strong demand and the desire to beat the scheduled step-down of the ITC at the end of 2020.

European solar expected to show strong growth in 2021

European solar growth remained relatively strong in 2020 despite the pandemic. European solar installs in 2020 rose by +8.0% to about 16.6 GW from 15.3 GW in 2019, according to BNEF. That added to the extremely strong growth years of +48% in 2018 and +98% in 2019.

In 2020, the largest PV install amounts were in Germany with 4.9 GW (+22% yr/yr), Netherlands 3.0 GW (+19%), Spain 2.8 GW (-45%), France 875 MW (-9%), and Italy 645 GW (-13%), according to BNEF.

European solar growth in 2020 continued to see support from the spread of subsidy-free solar throughout Europe and the EU's elimination in late 2018 of the minimum-price scheme. Also, Europe is mandating increasing amounts of solar power to meet its aggressive targets for cutting emissions.

Much of Europe's solar install growth in 2020 was driven by auctions for utility-scale solar in Germany, France, and Poland. Solar growth in Spain is being driven by subsidy-free power purchase agreements with both utilities and corporations.

European solar installs will continue to show strong growth in the coming years, with BNEF forecasting a +19% rise to 19.7 GW in 2021 and +11% to 22.0 GW in 2022.

A very large pipeline of subsidy-free solar projects in Europe will

contribute to installs in 2021 and 2022. BNEF reports that there is a huge 37.2 GW pipeline of unsubsidized solar projects in Europe that are scheduled to be built, with 6.6 GW of that due in 2021. BNEF reports that there are particularly large pipelines in Spain and Portugal.

European solar growth should receive a solid boost in coming years after the EU in July 2020 approved a big pandemic stimulus plan of 750 billion euros since almost one-third of those funds are targeted for fighting climate change. That added to the EU's 7-year budget that has 1 trillion euros of funding to help EU countries meet their EU's Paris Agreement goals for reducing carbon emissions.

European solar growth 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. Many solar projects in Europe are now being installed on an unsubsidized basis.

European solar growth is expected to show solid growth in the 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 on its renewables target to meet its pledge under the UN Paris climate agreement to cut its greenhouse gas emissions by at least 40% by 2030 from 1990 levels.

India's solar expected to recover after weak 2020

India's government is pushing solar very hard to modernize India's infrastructure, boost its global business competitiveness, expand electricity access in rural areas, and meet its climate goals.

The Indian 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. However, India is unlikely to meet that goal due in part to the pandemic disruptions in 2020. The 100 GW target is more than twice India's cumulative installed solar capacity of 48 GW as of the end of 2020.

India's solar installs in 2020 slowed sharply by -64% to 4.2 GW from 11.6 GW in 2019, according to BNEF. India's solar installs in 2020 were hurt mainly by the Covid pandemic, which caused

SOLAR PV GROWTH OUTLOOK (CONTINUED)

planning and construction delays and supply-chain disruptions. Also, solar developers pulled back due to the poor financial condition of electric utilities and their delayed payments to developers.

However, India's solar installs are expected to show a major recovery in 2021 and 2022 as delayed projects come online and as the government continues to push hard for more solar. India's solar installs in 2021 will grow by +183% to 11.97 GW, and will then show further growth of +2% in 2022 to 12.18 GW, according to forecasts by BNEF.

India's solar sector has seen serious disruptions over the past several years from the government's use of tariffs to encourage the development of domestic solar panel manufacturing capacity. The government tariff has made it difficult for solar installers to obtain reasonably-priced solar panels to meet their installation plans. However, the tariff has been sidestepped to some extent by sourcing panels from non-tariffed countries and by having solar plant owners pay the tariff for imported panels to get their plants finished on schedule.

The Indian government first implemented the 25% safeguard tariff on July 30, 2018, covering modules imported from developed countries, China, or Malaysia. The 2-year tariff started 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 next 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 then extended the tariff for another year at 14.9% for the 6-month period of July 30, 2020 to January 29, 2021, stepping down slightly to 14.5% for the next 6-month period of January 30, 2021 to July 29, 2021. In addition to developed countries and China, the new 2020-21 tariff also applies to Thailand and Vietnam. India dropped Malaysia as a country covered by the tariff.

Apart from the safeguard tariff, the Indian government in March 2021 announced that a 40% basic customs duty on solar modules, and a 25% duty on solar cells, will be imposed beginning in April 2022. That duty will be a further attempt to promote the development of solar panel and cell manufacturing capacity within India. However, India's solar manufacturing base remains far smaller than solar demand, meaning the duty is likely to hurt solar installers' ability to find enough reasonably-priced solar panels to meet the strong demand.

Japan's solar sees strong growth in 2020

Solar installs in Japan in 2020 rose sharply by +20% to 8.1 GW from 6.7 GW in 2019, according to BNEF. Solar growth was strong as developers sought to meet project completion deadlines in 2020 and 2021 to qualify for the solar feed-in-tariff (FIT), which is progressively stepping down.

Solar installs in Japan are expected to be negatively impacted by the phase-out of the government's generous FIT program for large-scale solar projects in 2022. BNEF is forecasting that Japan's solar installs will fall by -25% to 6.1 GW in 2021 and by -26% to 4.5 GW in 2022.

However, the Japanese government's support for solar will continue in the coming years. The government's FIT program will continue to support smaller-scale solar projects, while the government is developing a new feed-in-premium (FIP) support program for large-scale projects starting in 2022.

Solar in Japan should also see support in coming years from Japanese corporations looking to acquire solar power purchase agreements to meet their corporate renewable energy goals. Corporate demand is expected to drive the development of subsidy-free solar in Japan in the coming years.

Elsewhere in Asia, Taiwan is expected to see strong solar installs in coming years as the government promotes solar to meet its climate goals. Solar installs in Taiwan grew sharply by +41% to 1.4 GW in 2019 but then fell by -22% to 1.1 GW in 2020, according to BNEF.

Solar is seeing strong demand in Taiwan from corporations looking to meet their renewable energy goals. Also, there is rising demand for solar power in Taiwan to replace the coming closure of coal and nuclear plants. Taiwan's government is targeting a 25% renewable energy supply by 2025 and has announced an aggressive solar cumulative-capacity target of 20 GW by 2025, which would be four times the current cumulative capacity of about 5 GW.

South Korea is another bright spot for solar in Asia. Solar installs in South Korea grew sharply by +70% in 2018 and +62% in 2019, before tailing off to +5% growth in 2020 to 3.8 GW, according to BNEF.

Corporate demand for solar power is expected to grow sharply after South Korea's government in January 2021 revised its electricity laws to allow clean energy developers to sell electricity directly to corporations with power purchase agreements. The South Korean government in February also raised its mandate to 25% from 10% for the amount of annual renewable energy that electric utilities must source by 2030.

SOLAR PV ANNUAL NEW INSTALLATIONS

New global solar PV installations in 2020 grew by +21% yr/yr to a record 143 gigawatts (GW), according to Bloomberg New Energy Finance (BNEF). PV growth improved in 2020 from the weaker growth rates of +9% in 2018 and 2019 that were caused by temporary weakness in Chinese installs in 2018-19. Global solar PV installations have grown by a compounded annual rate of +21% over the last 5 years and have risen 8-fold from 2010.

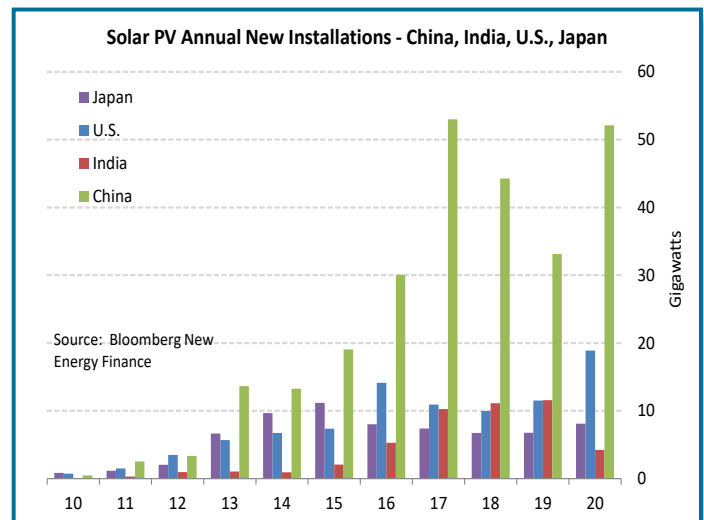
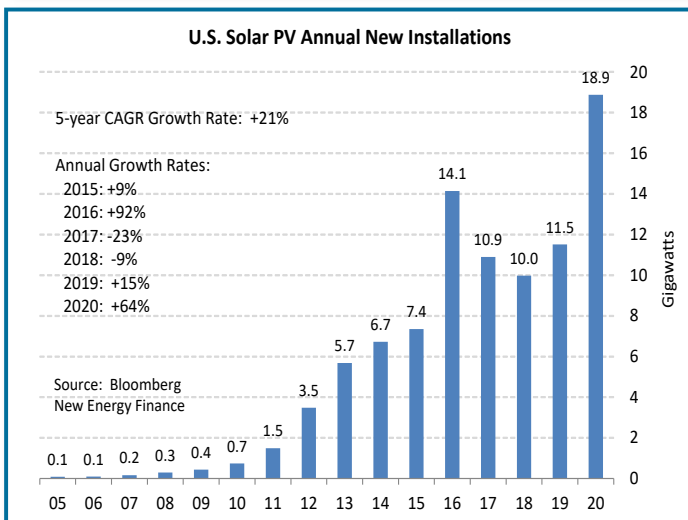
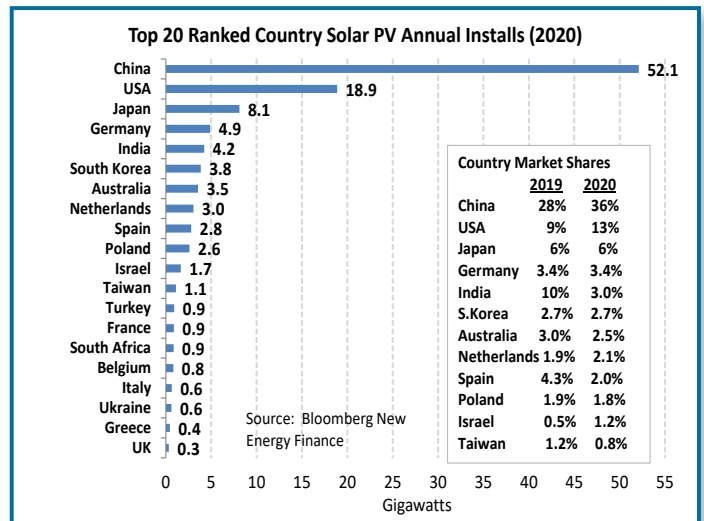
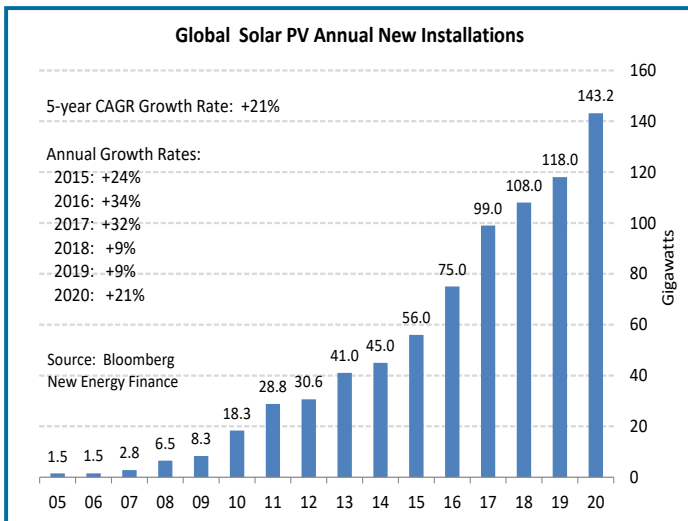
In 2020, China led the world for annual new solar PV installs for the seventh straight year with 52 GW of installs, up 57% from 2019 and just below the record of 53 GW posted in 2017, according to BNEF. The U.S. had a big year in 2020 with +64% growth to 18.9 GW, moving into second place for the most annual installs. Japan moved up to third place from fourth place with 8.1 GW of installs, up +20% yr/yr. Germany was in fourth place with 4.9 GW of installs (+22% yr/yr). India in 2020 fell to fifth place from second place, with 4.2 GW of installs (-63% yr/yr).

There were 12 countries in 2020 with installs above 1 GW, more

than the 7 such countries seen as recently as 2016-17. The global spread of solar illustrates how the industry is becoming more diversified and less dependent on growth rates in a few countries. Fitch forecasts that 36 nations will install more than 1 GW of solar by 2029.

Solar growth in Europe in 2020 grew by +8% yr/yr. The largest PV install amounts were in Germany with 4.9 GW (+22% yr/yr), Netherlands 3.0 GW (+19%), Spain 2.8 GW (-45%), France 875 MW (-9%), and Italy 645 MW (-13%), according to BNEF.

U.S. solar PV installations in the five years through 2020 grew at a compounded annual rate of +21% and rose 25-fold from 2010, according to BNEF. The states with the largest amount of new PV solar installations in 2020 were California with 3.9 GW (+26% yr/yr), Texas 3.4 GW (+143%), Florida 2.8 GW (+107%), Virginia 1.4 GW (+965%), North Carolina 785 MW (-19%), South Carolina 617 MW (+20%), New York 544 MW (+15%), Arizona 503 MW (-45%), and Utah 427 MW (+250%), according to Wood Mackenzie.



SOLAR PV CUMULATIVE INSTALLATIONS

The amount of cumulative PV electricity generation capacity across the world in 2020 grew sharply by +22% yr/yr to 787 GW, 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 244 GW in 2015 to 787 GW in 2020, representing a compounded annual growth rate of +26%.

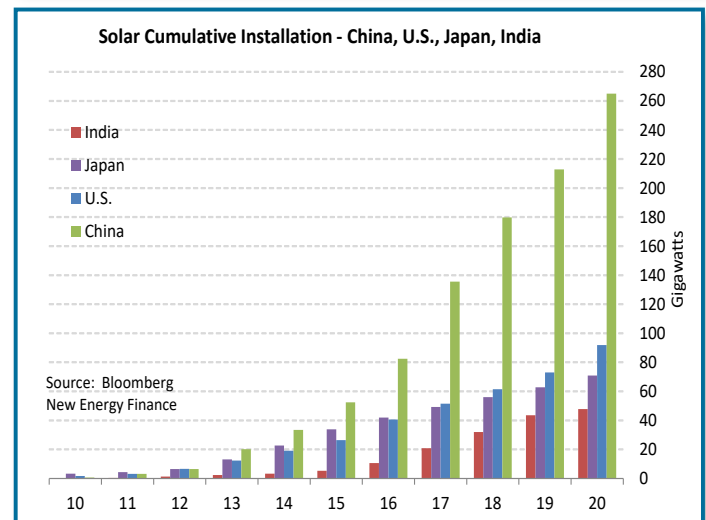
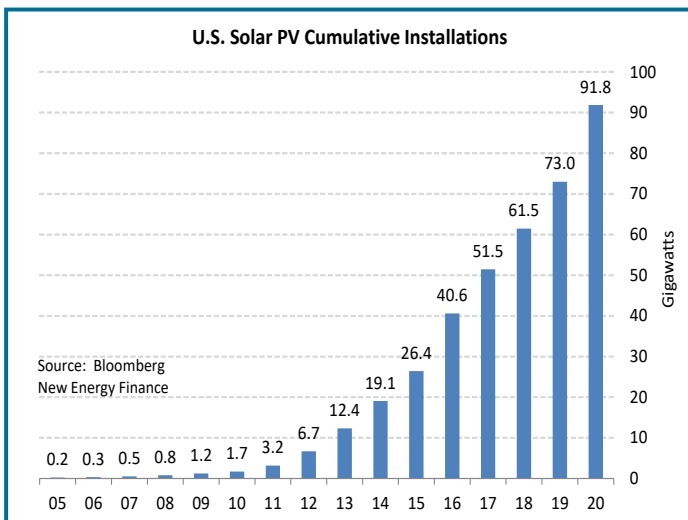
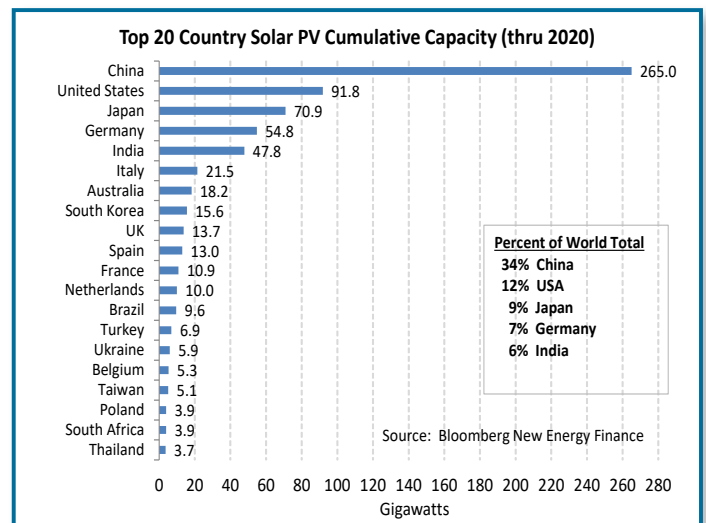
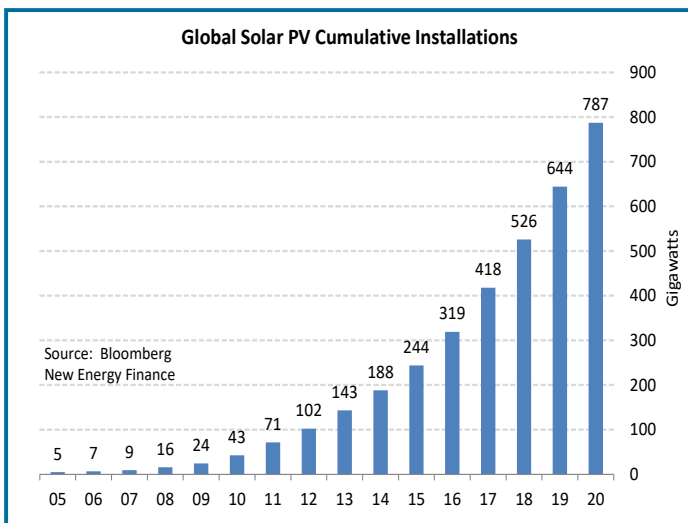
China in 2020 continued to be the world's leader for cumulative solar capacity at 265 GW, according to BNEF. China at the end of 2019 accounted for 34% of the world's solar PV capacity. In the past five years, China's cumulative installed solar capacity soared by 5-fold from 52 GW in 2015 to the 2020 level of 265 GW, representing a 5-year compounded annual growth rate of +38%.

The U.S. in 2020 remained in second place for cumulative solar installs. U.S. solar electricity capacity in 2020 rose by +26% to

92 GW, representing 12% of world capacity. Over the past five years, U.S. cumulative solar electricity capacity rose by more than 3-fold to 92 GW from 26 GW in 2015 and showed a compounded annual growth rate of +28%.

Japan remained in third place for the seventh straight year. Japan's cumulative solar capacity in 2020 rose by +13% to 71 GW, representing 9% of world capacity. Japan's cumulative solar capacity in the past five years has risen by 2.1-fold to 71 GW from 34 GW in 2015, representing a 5-year compounded annual growth rate of +16%.

Germany in 2020 remained in fourth place with 55 GW of cumulative solar PV capacity, up +10% yr/yr. Germany's cumulative solar capacity in the past five years has risen 1.4-fold to 54 GW from 39 GW in 2015. Germany, at the end of 2020, accounted for 7% of the world's total solar PV capacity.



LEVELIZED COST OF SOLAR ELECTRICITY

Solar's electricity cost falls -9% and beats fossil fuels and nuclear by even larger amounts

The levelized cost of electricity (LCOE) for newly-built U.S. utility-scale crystalline solar PV plants in late-2020 fell by -9% yr/yr to a midpoint of \$36.5 per MWh (\$31-42 range) on an unsubsidized basis, according to Lazard in the latest annual edition of its comprehensive "Levelized Cost of Energy Analysis-Version 14.0" released in November 2020. That added to the declines of -7% in 2019 and -13% in 2018.

The LCOE for utility-scale PV has now plunged by an overall -85% from \$248/MWh in 2010, and has fallen by an average of -11% per year over the past five years.

The cost of community solar and residential PV systems also fell. Lazard reports that the unsubsidized mid-point LCOEs in 2020 fell by -26% yr/yr for Community Solar to \$78.5/MWh (\$63-94 range) and -4% yr/yr for Rooftop Residential to \$188.5/MWh (\$150-227). The mid-point LCOE for Rooftop Commercial and Industrial rose by +10% to \$126.5/MWh (\$74-179 range), but that was caused by a rise in the upper range to \$179 from \$154 in 2019. The lower range for Rooftop C&I fell slightly to \$74/MWh from \$75 in 2019.

The Lazard report found that the mid-point cost for utility-scale crystalline solar PV of \$36.5/MWh is now 67% cheaper than the \$109/MWh mid-point cost for newly-built coal plants, 78% cheaper than the \$163.5/MWh mid-point cost for nuclear plants, 79%

cheaper than the \$174.5/MWh mid-point cost for gas-peaking plants, and 38% cheaper than the mid-point cost of \$58.5/MWh for natural gas plants.

The Lazard data shows that on average it is no longer economical for a utility to build any new coal, nuclear, or natural gas plants.

Moreover, solar has become so inexpensive that it is now cheaper to build a brand new PV utility-scale solar plant from scratch for \$36.5/MWh than it is to keep an existing coal plant running at a marginal cost of \$41/MWh. However, installing a new solar plant does not yet beat the marginal cost of keeping an existing nuclear plant running of \$29/MWh or a natural gas plant of \$28/MWh.

Solar has big potential as a replacement technology since many coal and nuclear plants are reaching the end of their useful lives, with an average age of 40 years for U.S. coal plants and 38 years for U.S. nuclear plants. As coal and nuclear plants are retired, utilities will decide to switch to building new solar, wind, and gas plants based on economics, with gas having some preference for baseload until storage starts to play a bigger role in supporting solar as a 24/7 baseload electricity resource.

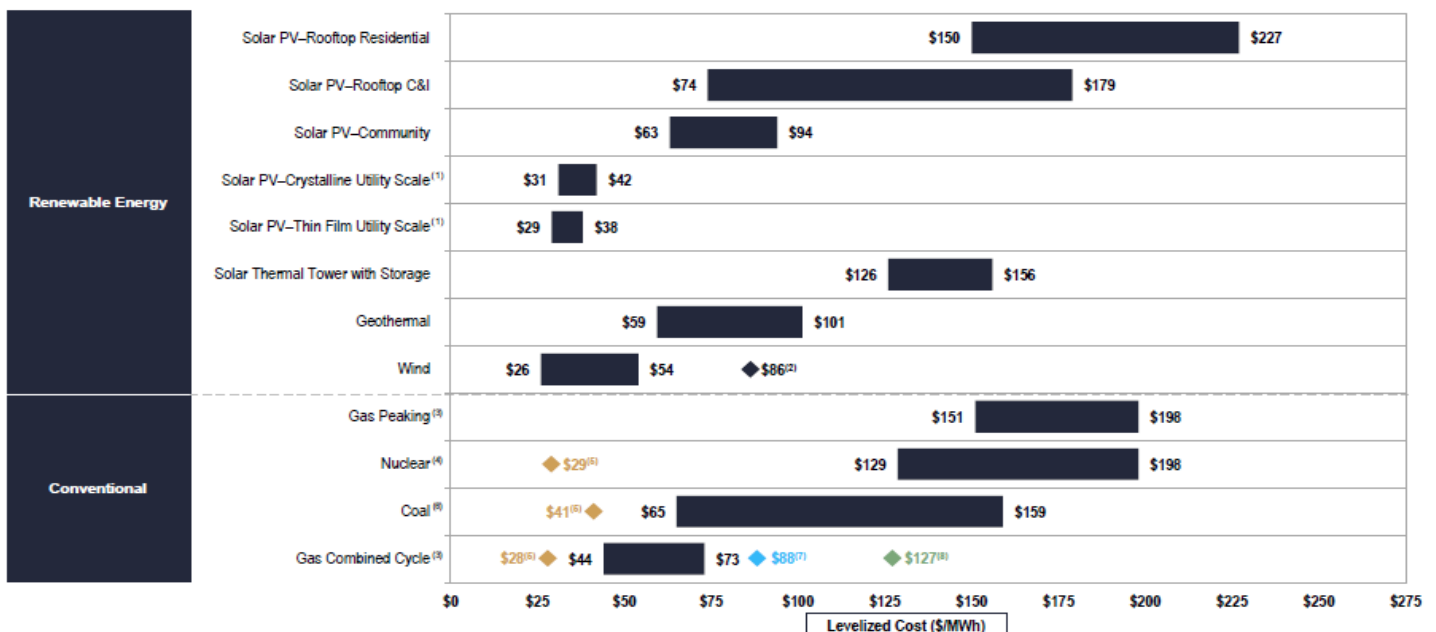
Solar has become cheaper than new fossil fuel plants, not just in the U.S., but also globally. BNEF reports that it is already cheaper for two-thirds of the world's population to get new power from solar or wind than from new fossil fuel plants.

LAZARD

LAZARD'S LEVELIZED COST OF ENERGY ANALYSIS—VERSION 14.0

Levelized Cost of Energy Comparison—Unsubsidized Analysis

Selected renewable energy generation technologies are cost-competitive with conventional generation technologies under certain circumstances



Source: Lazard's Levelized Cost of Energy Analysis - November 2020, Version 14.0.

PRICING - SOLAR MODULES, CELLS, AND POLYSILICON

Solar module prices have been moving sideways since mid-2020. The price of silicon solar modules fell to a new record low of 16.3 cents per watt in July 2020 but has since recovered slightly to the current level of 17.8 cents, according to PV Insights. Since 2010, silicon module prices have plunged by a total of -89%.

The price of thin-film modules fell to a record low of 20.7 cents per watt in July 2020 but has since recovered slightly to 21.3 cents, according to PV Insights. Since 2010, thin-film module prices have plunged by a total of -84%.

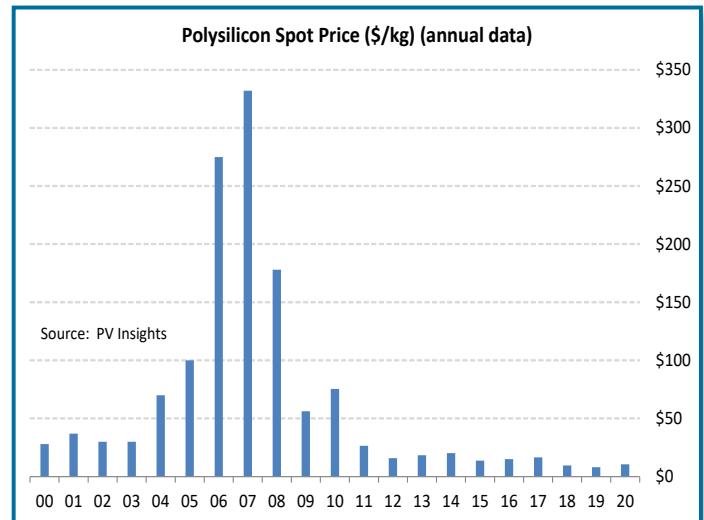
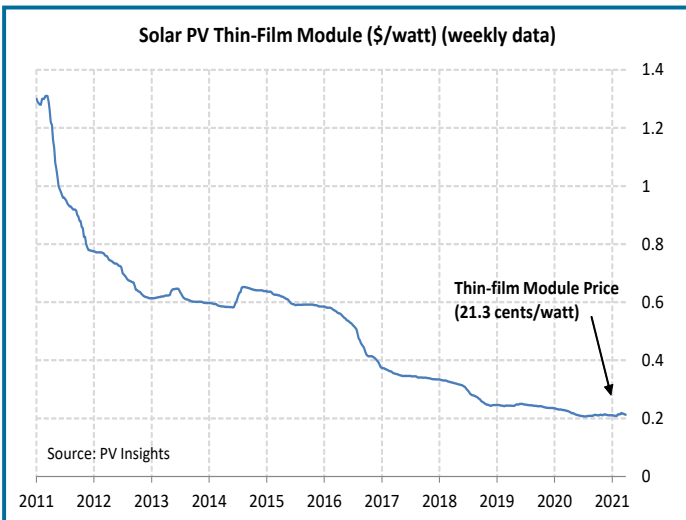
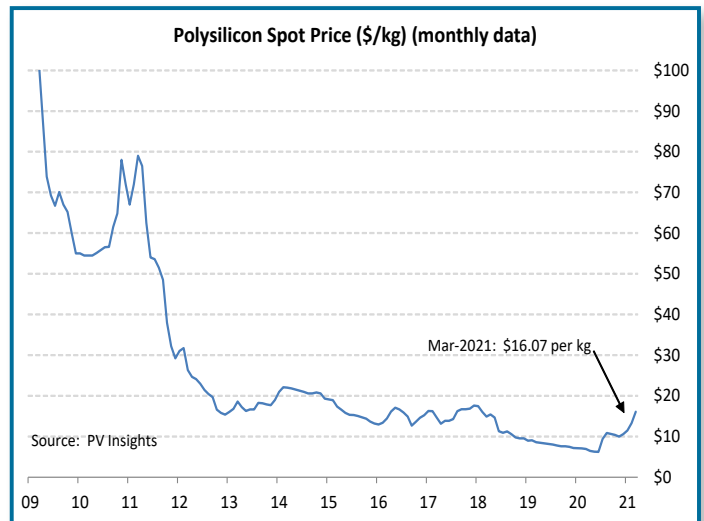
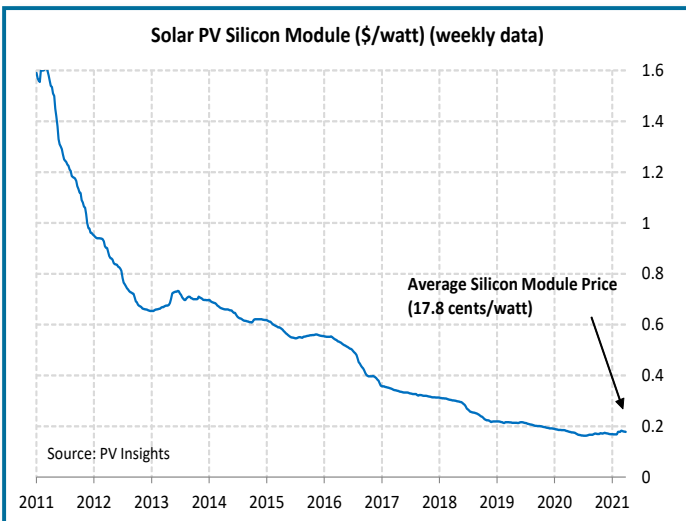
Solar module prices have moved mildly lower in recent years due to the natural decline in solar pricing that results from lower production costs caused by technology advances and manufacturing economies of scale.

Spot polysilicon prices fell to a record low of \$6.90 per kg in May 2020 but have since spiked higher to \$16.07, according to PV Insights. Polysilicon prices have plunged by -77% since 2010.

Polysilicon prices fell to a record low during the worst of the pandemic shutdowns in spring 2020, but then rebounded higher as two major polysilicon manufacturers were forced to close down their plants due to a fire in one case and flooding in the other case.

Solar module pricing since the beginning of 2019 has stabilized following previous sharp declines. In 2018, solar pricing fell sharply due to the oversupply situation caused by the Chinese government's sharp cutback of subsidies with its May 31, 2018 order (China-531). Separately, solar prices fell sharply in the second half of 2016 because of a module oversupply situation that followed solar install spikes in China and the U.S. caused by developers trying to beat respective national subsidy-reduction deadlines.

Solar pricing has become more stable in the past few years as solar subsidies are phased out, reducing the risk of previous subsidy-related boom-bust cycles.



SOLAR JOBS

U.S. solar jobs in 2019 rose by +3% to 249,983 jobs from 242,343 jobs in 2018, according to the "National Solar Jobs Census 2019" published by The Solar Foundation in February 2020. Solar jobs rose in 2019 and broke the 2-year string of job losses in 2017-18, but remained below the record high of 260,077 jobs seen in 2016.

Solar jobs in early 2020 took a sharp hit due to the pandemic shutdowns, as did the U.S. labor market as a whole. However, solar jobs were already in a partial recovery mode in the second half of 2020.

The U.S. solar industry during the 9-year period of 2010-2019 added a net total of 156,000 jobs to the U.S. economy, rising by a total of +167% over that period.

Solar employment in the nine years through 2019 grew seven times faster than the +1.8% annual growth rate of the U.S. economy, according to the Solar Foundation. That illustrates 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 14% of total solar jobs, according to the Solar Foundation.

Solar jobs in 2019 increased as the solar sector regained some upside momentum after seeing declines in solar jobs in 2017 and 2018. The decline in jobs in 2017-18 was due to fewer solar installs after the growth spike seen in 2016 and 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.

Solar jobs in the U.S. substantially exceed those in the fossil fuel industries. Specifically, the 249,983 jobs in the solar sector far exceed the 157,900 direct jobs in the oil/gas extraction industry and 51,100 direct jobs in the coal mining industry at the end of 2019, according to figures from the U.S. Bureau of Labor Statistics (see chart on the right).

Globally, solar PV is a huge employer, with 3.75 million solar jobs worldwide at the end of 2019, up by +2% from 3.68 million in 2018, according to the "Renewable Energy and Jobs--Annual Review 2020" from the International Renewable Energy Agency (IRENA).

China is far ahead of the U.S. in solar PV jobs with a total of about 2.2 million jobs due to its much larger installation and manufacturing solar sector, according to the IRENA report. Countries other than China and the U.S. with large solar PV employment include Japan with 241,000 jobs, India with 204,000 jobs, and EU with 127,300 jobs, according to IRENA.

