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MAC Solar Index

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SOLAR SECTOR UPDATE

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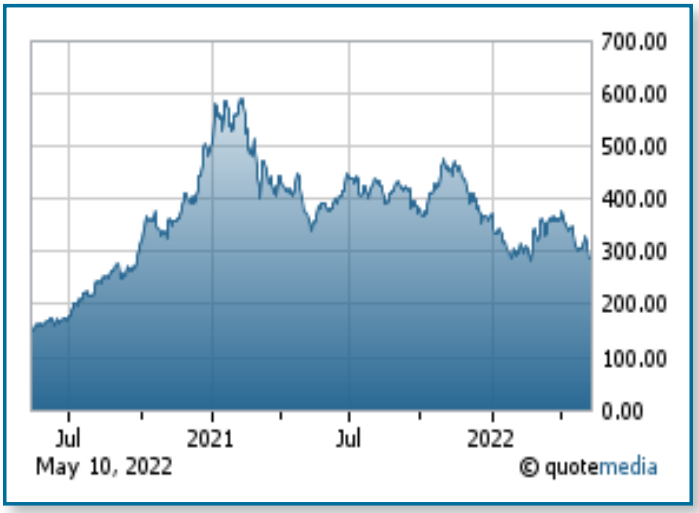
MAC Global Solar Energy Index (SUNIDX)



SOLAR INDEX PERFORMANCE

The MAC Global Solar Energy Stock Index, the tracking index for the U.S.-based Invesco Solar ETF (NYSE ARCA: TAN) and the European-based Invesco Solar Energy UCITS ETF (ISUN LN, RAYS LN, SOLR GY, SOLR IM, SOLR SW), has fallen back in the past year since posting a 13-year high in January 2021. The Index is currently down by -21% on a year-to-date basis. That adds to the -26% decline in 2021 but doesn't come close to reversing the extraordinary gains of 67% seen in 2019 and +245% seen in 2020.

The MAC Solar Index has fallen back this year as part of the downward correction seen in the overall stock market, caused by concern about high inflation, weaker global economic growth, and rising interest rates. Solar stocks are also seeing weakness due to the U.S. Department of Commerce's tariff investigation, some minor disruptions to U.S. panel imports due to the new Xinjiang law, and the inability of Congress as yet to pass at least the renewable energy provisions in President Biden's Build Back Better bill.

Despite the recent obstacles, bullish longer-term factors for solar stocks continue to include (1) the global dash to reduce carbon emissions as many countries are now adopting net zero emissions goals to add to their Paris climate agreement goals, (2) strong demand for solar by many global corporations that have recently adopted net zero emissions goals, (3) strong economic demand for solar now that solar is cheaper to build than fossil fuel or nuclear power in most of the world, (4) the pairing of solar with ever-cheaper battery systems to provide a 24/7 electricity solution, and (5) the increased focus by many nations to improve their energy security by building domestic electricity infrastructure such as solar, thus freeing themselves from the energy risk of importing fossil fuels from potentially hostile nations.

Solar stocks settle back but long-term industry trends remain bullish

Solar stocks have fallen in 2022 along with the rest of the stock market, which is seeing a post-pandemic correction caused by concern about high inflation, weaker global economic growth, and rising interest rates. The MAC Solar Index is currently down -21% year-to-date, which is less than the -24% year-to-date decline in the Nasdaq 100 index.

Yet solar stocks are still up by about 90% from their pre-pandemic level and the long-term prospects for the solar industry look very strong. Demand for solar is soaring across the world due to solar's cost-competitiveness and the dash for net-zero emissions by many nations and global corporations. In fact, solar demand is so strong that it has far outstripped the supply of available panels, which means the solar growth rate would be much higher if enough panels were available. This demand will be met before long since many solar companies in recent months have announced massive manufacturing capacity additions.

The global solar industry in recent years has proven its resilience by adapting to rising demand and quickly shifting government policies. The solar industry was able to easily shake off the pandemic and showed very strong growth rates of +23% in 2020 and +27% in 2021, according to data from Bloomberg New Energy Finance. The long-term growth theme for the solar industry remains intact, with BNEF forecasting +33% yr/yr solar growth in 2022 and more than $4 trillion of solar spending through 2050.

SOLAR PV GROWTH OUTLOOK

Global solar growth is expected to show another strong year in 2022 as demand surges across the globe. Bloomberg New Energy Finance (BNEF) is forecasting that solar installs in 2022 will surge by another 33% to 246 GW, which would be the fourth consecutive year of double-digit growth.

In 2021, global solar growth soared by +27% to 184 GW, adding to the growth rates of +11% seen in 2019 and +23% seen in 2020, according to BNEF. New global solar installs grew by a compounded annual growth rate of +20% over the 5-year period through 2021.

Demand for solar has soared in the past several years as solar becomes cheaper than competitors and as nations and corporations are racing to meet net zero emissions targets. Many countries, especially in Europe, are also taking energy security more seriously and are focused on building domestic infrastructure such as solar to produce their electricity rather than relying on unreliable fossil fuels from foreign sources.

The solar industry over the past two years has shown very strong growth and has been able to shake off obstacles such as pandemic shutdowns, higher commodity prices, supply chain constraints, higher shipping costs, and trade/geopolitical barriers.

The long-term outlook for solar looks very bright. 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 world level of 11% and easily the largest source of electricity generation.

"I see solar becoming the king of the world's electricity markets, Fatih Birol, executive director of the International Energy Agency (IEA), said in 2021 with 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 decline and 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 -8% per year over the last five years, according to Lazard (see p. 11).

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

The Chinese solar market remains strong as the country shifts toward a subsidy-free solar market and relies on solar to provide the power it needs to fuel rapid economic development, phase out coal, improve its air quality, and meet its emissions goals.

The Chinese government is relying heavily on solar to meet increasingly aggressive climate targets. In October 2021, the Chinese government adopted the goal for carbon emissions to peak before 2030 and for carbon-neutrality by 2060 as part of its National Determination Contribution (NDC) under the Paris Climate Agreement.

To meet its NDC goals, China has adopted a target of generating 25% of its electricity from non-fossil fuel sources by 2030. China also reiterated its target of achieving 1,200 GW of renewable energy capacity by 2030, with 619 GW of solar by 2030.

In order to help meet that dramatic renewables goal, China has begun work on a massive set of solar and wind projects in its desert regions. The first phase of 97 GW of solar and wind began in 2021 and has been running smoothly, leading the government to expand the project. The Chinese government has now announced another 455 GW of desert solar and wind projects, with 200 GW of that slated to be built by 2025 and another 255 GW to be built by 2030. The bulk of the generated electricity will be delivered to the populated eastern regions of the nation.

Turning to solar growth rates, Chinese solar installs in 2021 soared by +32% to a new record high of 68.6 GW, adding to the very strong growth rate of +57% seen in 2020 to 52.1 GW, according to BNEF. China's solar surge is expected to continue in 2022 with BNEF forecasting growth of +48% to 101.4 GW.

Chinese solar growth was strong in 2020-21 despite the disruptions caused by the Covid pandemic and the transition in China to a solar market without national subsidies. Developers are showing strong interest in subsidy-free solar projects 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.

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

SOLAR PV GROWTH OUTLOOK (CONTINUED)

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.

By contrast, the Chinese solar market in recent years has been buffeted by erratic subsidy policies that 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.

Regarding Chinese labor issues, the U.S. government in June 2021 imposed a "withhold release order" that blocked the import of polysilicon products produced by five companies based in China's Xinjiang province due to allegations the companies were involved with forced labor programs of the Uyghur Muslim minority. The Biden administration also placed those companies on the Treasury's Entity List, which blocks U.S. exports to those companies.

At least one of the targeted companies strenuously denied the use of forced labor. In order to rebut the claims, the company hired a global auditor to study its workforce practices and opened its Xinjiang factory to tours by global equity analysts and investors.

The U.S. Congress in December then passed the Uyghur Forced Labor Prevention Act, which was signed into law by President Biden. The law bans the import into the U.S. of products made in Xinjiang unless the importer can prove that the products were not made with forced labor.

The global solar industry is adjusting to the Xinjiang labor issues by building new polysilicon plants outside Xinjiang and creating supply chain documentation. Factories in the Xinjiang region produced about 45% of the world's solar-grade polysilicon in 2020, according to Bernreuter Research. Many companies have announced plans to build new polysilicon plants outside Xinjiang to make it easier to comply with the new U.S. rules.

The U.S. ban on importing non-documented solar products from Xinjiang has caused some supply-chain disruptions for U.S. solar developers, who have had shipments temporarily detained by U.S. Customs until they provided the necessary documentation.

However, the overall impact of the ban has been reduced by the fact that the U.S. only buys a small portion of China's solar module output in the first place due to U.S. tariffs on Chinese solar products.

Also, the U.S. accounted for only 13% of global solar installs in 2021, which means that the impact of the U.S. ban on forced-labor products from Xinjiang has had only a minor impact on the overall global solar growth rate.

U.S. and global solar companies have been aware of the Xinjiang risk for the last two years and have already been taking steps to divert supplies away from Xinjiang and do a better job of ensuring transparency and documenting their supply chains.

The global solar industry, as a whole, is taking specific steps to address allegations of forced labor. About 175 solar companies from around the world signed a pledge sponsored by the Solar Energy Industries Association (SEIA) to ensure that their supply chains are free of any forced-labor products (see "Solar Companies Unite to Prevent Forced Labor in the Solar Supply Chain"). The SEIA also released a Supply Chain Traceability Protocol that helps companies prove that their supply chain is free of any products that are potentially connected with forced labor (see "New Traceability Protocol Allows Solar Companies to Ensure Ethical Supply Chain").

U.S. solar demand remains very strong but panel supply is an issue

U.S. solar growth in 2021 saw continued strength with +28% yr/yr growth to a new record 23.9 GW, adding to the +62% yr/yr surge seen in 2020, according to BNEF.

Utility-scale solar accounted for 73% of the U.S. solar installs in 2021, followed by 17% for residential solar, and 10% for commercial and community solar, according to Wood Mackenzie's "U.S Solar Insight - 2021 Year in Review."

Solar accounted for an impressive 46% of new U.S. electricity installs in 2021, which was a record high and up from 43% in 2020 and 40% in 2019, according to Wood Mackenzie. Solar accounted for only 3.9% of U.S. electricity generation in 2021, showing that there is plenty of headroom for massive solar growth in the coming decades.

Solar remained first among all the electricity generation technologies for the third straight year, beating the 44% share for wind and 10% share for natural gas. The share of new natural gas U.S. electricity additions fell further to 10% in 2021 from 18% in 2020 and from 57% as recently as 2018. Solar and wind together accounted for a combined 90% of new electricity capacity installs and shoved aside natural gas. Neither coal or nuclear registered any significant new installs in 2021, according to Wood Mackenzie.

SOLAR PV GROWTH OUTLOOK (CONTINUED)

U.S. solar growth in 2021 was driven by strong demand and overcame various obstacles such as the pandemic, supply chain disruptions, high commodity input prices, and U.S. trade and geopolitical barriers.

Solar installs in 2020 and 2021 saw support as developers sought to take advantage of the investment tax credit (ITC), which allows developers to receive a partial tax credit for solar installations.

The solar ITC of 26% in 2020 was due to step down to 22% in 2021 and 10% in 2022 for utility PV projects, non-residential, and third-party-owned residential solar projects (and to zero for direct-owned residential projects).

However, Congress in December 2020 extended the solar ITC as part of the combined passage of the $900 billion pandemic aid bill and the $1.4 trillion omnibus spending bill. The new legislation set the ITC at 26% for 2021 and 2022, with a step-down to 22% in 2023. In 2024, the ITC will be set at 10% indefinitely for large-scale solar projects and at zero for small-scale solar projects.

There is no doubt that there is very strong demand for solar in the U.S. from all sectors, including residential, distributed solar at commercial and community locations, corporate demand for solar power purchase agreements (PPAs) to meet net-zero emissions targets, and utility-scale solar.

However, there are questions about whether this demand can be met because of various actions by the U.S. government that have restricted the supply of solar panels available to U.S. developers. These restrictions include the new U.S. law on Xinjiang and a new tariff investigation by the U.S. Department of Commerce.

Specifically, the Department of Commerce in March 2022 opened an investigation into whether Chinese companies are circumventing the decade-old antidumping and countervailing (AD/CVD) tariffs with their factories in Malaysia, Thailand, Vietnam, and Cambodia. Those countries currently account for about 80% of the almost $7 billion of solar products that the U.S. imports annually, according to Bloomberg.

The probe was started due to a petition filed by a small U.S. solar company, Auxin Solar, which would benefit from extended tariffs by seeing less competition from Asian solar suppliers.

The DOC investigation has already sparked a flurry of order cancellations and project delays by U.S. developers, who are not willing to risk that large tariffs could be imposed retroactively by the DOC, thus dramatically increasing the costs of their projects.

The deadline for the DOC to make a preliminary determination on the investigation is August 2022, and final determination might not come until between January and April 2023. In the meantime, the Commerce Department has thrown the U.S. solar industry into turmoil with its antiquated investigation procedures that are based on a 92-year-old trade law.

In any case, there is a great deal of pressure on the Department of Commerce to get its investigation over with quickly. A group of 22 U.S. Senators sent a letter to President Biden pleading for a quick conclusion to the solar probe. Various clean energy organizations and companies are also applying pressure to get the investigation resolved as soon as possible.

U.S. Commerce Secretary Gina Raimondo, in early May 2022, indicated that her department would move as quickly as possible on the investigation by saying, "This case has my attention, we are focused on it, and we're doing everything we can to move it as swiftly as we can in the confines of the law. Any place that we can accelerate within the bounds of the law, we are doing that."

The good news for the global solar industry as a whole is that the U.S. investigation affects only U.S. solar installs, which represented only 13% of global solar installs in 2021. If the U.S. government wants to block certain panels from being imported into the U.S., those panels will quickly be snapped up by buyers in many other countries where demand is booming and the overall global solar install rate will remain strong. Moreover, the U.S. investigation will only have a temporary effect on U.S. installs, which can return to strong levels in line with demand once the uncertainty from the investigation passes.

Separately on the tariff front, the Biden administration in February 2022 extended former-President Trump's Section 201 tariffs on imported solar panels at 14-15% for another four years. However, the administration allowed a continued exemption for bifacial panels and also doubled the import quota for duty-free solar cells to 5 GW.

The exemption for bifacial panels was considered a big win for solar developers and buyers since those panels are widely used by large utility-scale projects. The U.S. solar industry has already migrated to bifacial panels because they use-effective technology and have been exempted from tariffs the last two years because of a mistake made by the former Trump administration that it couldn't correct before leaving office. Bifacial panels allow light to be absorbed by both the front of the panel and back of the panel as light bounces off the ground.

Regarding the history of the U.S. 201 tariffs, former-President Trump in January 2018 imposed a Section 201 tariff of 30% on imported solar cells and modules in an attempt to protect the few existing U.S. solar manufacturers. The initial Section 201 import tariff of 30% for 2018 stepped down to 25% in February 2019, 20% in February 2020, and 15% in February 2021. The tariff was set to expire in February 2022, but as mentioned earlier, President Biden then extended the tariff for another four years.

Elsewhere on the policy front, the solar industry continues to wait

SOLAR PV GROWTH OUTLOOK (CONTINUED)

to see whether Congress, before the November 2022 mid-term elections, will pass any part of President Biden's $1.7 trillion Build Back Better bill, such as the $550 billion of energy and climate spending.

The energy provisions of the Build Back Better bill contain an extension of the solar investment tax credit (ITC), and also 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 Build Back Better proposal also has a production tax credit for U.S. solar manufacturers. The bill also has a new ITC for battery storage, which would give solar-plus-storage a big boost.

Those energy measures could be passed by Congress as separate legislation or as add-ons to must-pass legislation such as an omnibus spending bill to fund the U.S. government.

Since taking office in January 2021, the Biden administration has taken a number of executive actions on the climate front. 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.

The Biden administration, in April 2021, announced a new "Nationally Determined Contribution" under the Paris Climate Agreement of a reduction in U.S. greenhouse gas emissions by 50-52% by 2030 from 2005 levels. That was nearly double the previous commitment made by President Obama of a 26-28% cut in greenhouse gas emissions by 2025 from 2005 levels. The NDC also included the target of the U.S. economy having net-zero carbon emissions by 2050.

In December 2021, President Biden signed an executive order to cut the federal government's emissions by 65% by 2035 and make the government carbon neutral by 2050, the same year that carbon neutrality is targeted for the U.S. economy as a whole. As part of that order, the U.S. government is instructed to have 100% carbon pollution-free electricity by 2030, which is only eight years away.

Explaining the order, the White House said, "The federal government will work with utilities, developers, technology firms, financiers, and others to purchase electricity produced from resources that generate no carbon emissions, including solar and wind, for all its operations by 2030."

European solar expected to show continued strong growth

European solar growth in 2021 grew sharply by +34% yr/yr to a new record high of 25.9 GW, according to the "EU Market Outlook for Solar Power" reported published by SolarPower Europe. That was the fourth consecutive year of very strong solar growth for Europe. Solar now produces 6% of Europe's electricity, according to thinktank Amber.

In 2021, the largest European national solar install amounts were in Germany with 5.3 GW (+8% yr/yr), Spain with 4.6 GW (+50% yr/yr), Netherlands with 3.6 GW (+4% yr/yr), Poland with 3.2 GW (+21%), and France with 2.5 GW (+154%), according to BNEF.

European solar growth in 2020 and 2021 continued to see strong support from the spread of subsidy-free solar throughout Europe after the EU's elimination in late 2018 of solar tariffs and the minimum-price scheme. Also, Europe is mandating increasing amounts of solar power to meet its aggressive targets for cutting 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 causing many years of very slow solar growth in Europe.

The end of the MIP scheme, combined with the sharp drop in solar module prices seen in recent years, 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 also receiving a boost from the EU's pandemic stimulus plan, approved in July 2020, which totaled 750 billion euros, since almost one-third of those funds were 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 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 European Commission in July 2021, as part of its "Fit for 55" package, proposed raising that renewable energy target to 40%, with that proposal going to the European Parliament and its members for approval.

The EU is relying on its renewables target to meet its pledge under the UN Paris climate agreement to cut its greenhouse gas

SOLAR PV GROWTH OUTLOOK (CONTINUED)

emissions by at least 55% by 2030 from 1990 levels, and for net zero emissions by 2050.

Europe was thrown into an energy emergency after Russia invaded Ukraine in February 2022 and Europe came under pressure to quickly slash its dependence on Russian oil and gas. The EU imports 90% of its natural gas consumption, and Russia provides about 45% of those gas imports, according to data from the European Commission. The Commission also notes that Europe depends on Russia for about 25% of its oil imports and 45% of its coal imports. Europe currently derives about 20% of its electricity from natural gas, according to PV Tech.

Sanctions on Russia's oil and gas industries have driven natural gas prices sharply higher, which makes solar even more price-competitive against gas. That provides another reminder that solar is not only a good environmental solution, it is also a good economic solution as well. The UK's secretary of state for Business, Energy and Industrial Strategy (BEIS), Kwasi Kwarteng, said, "Renewables are cheaper than gas. The more cheap, clean power we generate at home, the less exposed we'll be to global gas markets."

Russia's invasion of Ukraine brought the importance of domestic energy security to the forefront once again, much as it was in the 1970's when OPEC's oil embargo caused long gasoline lines and a global recession. Fossil fuels tend to come from hostile and inhospitable places, making them an unreliable and risky source of energy for importers.

As a result of Russia's attack on Ukraine, the EU is formulating a new plan called REPowerEU to reduce its dependence on Russian fossil fuels. The EU is planning to end most of its crude oil imports from Russia by the end of 2022 and reduce its natural gas imports from Russia by two-thirds by the end of 2022. In response to Russia's invasion of Ukraine, Germany in February already scrapped the whole approval process for the Nord Stream 2 gas pipeline from Russia to the EU, putting the project into an indefinite freeze and forced the Gazprom-backed Nord Stream company towards insolvency.

A key strategy of REPower EU is to rapidly build new alternative energy capacity to replace the need for natural gas and coal to generate electricity. The RePowerEU proposal seeks to ensure that 420 GW of new solar is installed in the EU by 2030, which would bring installed capacity to 565 GW. That would require the average annual solar installation of 47 GW of solar over the next nine years, which is about 80% higher than the 2021 install level of 26 GW.

The EU's climate policy chief, Frans Timmermans, said, "Let's dash into renewable energy at lightning speed. Renewables are a cheap, clean and potentially endless source of energy, and instead of funding the fossil fuel industry elsewhere, they create jobs here."

The REPower EU strategy includes several key measures for speeding the installation of solar, including larger government solar auctions, government help in identifying land sites, streamlining permitting, and streamlining solar Power Purchase Agreements (PPAs) to make them more attractive for small and medium-sized companies.

India's solar demand expected to remain very strong

India's government is pushing solar very hard as a means to modernize India's infrastructure, boost its global business competitiveness, expand electricity access in rural areas, and meet its climate goals. India, at the COP26 conference in late 2021, announced national goals of 500 GW of renewable capacity by 2030 and net zero emissions by 2070.

India's government has set an aggressive goal for installing 280 GW of cumulative solar capacity by 2030, which is more than four times the current installed level of 60 GW seen at the end of 2021. In order to reach that target, India would need to install an average of about 31 GW per year from 2022 through 2030, which would be more than double India's 2021 annual install rate of 12 GW.

In 2021, India installed the third most solar of any country in the world behind China and the U.S. In 2021, India installed a record 12.4 GW of solar, recovering by +192% from 2020's dismal install level of 4.2 GW that was caused in part by the pandemic, according to BNEF data. BNEF is forecasting that India's solar growth rate will remain strong at a compounded annual rate of +14% over the next five years and more than triple to an annual install rate of 47 GW by 2030.

Solar is already big business in India, accounting for 62% of new power capacity additions and accounting for about 12.4% of India's installed power capacity at the end of 2021, according to PV Tech. Solar also provides India's largest source of alternative power, with solar representing 47% of total renewable power generation, ahead of 48% for wind, 10% for biopower, and 5% for small hydro, according to PV Tech.

Over the near-term, however, India has been running into obstacles as it tries to reduce its reliance on Chinese solar panels and encourage the construction of solar manufacturing plants located inside India. In 2020, India imported about 80% of its solar panels from China.

India is currently using a combination of steep tariffs on Chinese solar panels and domestic manufacturing subsidies to try to promote a homegrown solar industry. So far, India's domestic manufacturing capacity of 8.8 GW for solar modules and 2.5 GW for solar cells is far below India's 2021 annual solar install level of 12.4 GW, according to PV Tech. India's solar manufacturers, therefore, remain woefully short of meeting India's outsized demand. There are the additional problems that India-made solar

SOLAR PV GROWTH OUTLOOK (CONTINUED)

panels tend to be expensive and do not utilize the latest solar technologies.

India's government, in recent years, has made some progress on the domestic production front by using a variety of tariffs and incentives. However, demand for solar panels in India still far outstrips supply. In fact, some solar developers are currently curbing their solar building plans in India because of the shortage and the high price of the limited number of panels that are currently available domestically in India.

The Indian government's new and more aggressive industrial policy plan, although it will take time, may have some success in weaning the country off Chinese modules. In the meantime, however, the Indian government's policies are restricting the supply of reasonably-priced panels that are available to solar developers in India.

On the tariff side, India's government, as of April 1, 2022, imposed a new basic customs duty of 40% on the import of solar modules and a 25% duty on cells. India also maintains an "Approved List of Models and Manufacturers" (ALMN) of solar panels that are approved for installation in India. That list that was originally designed as a minimum quality requirement, but there is now speculation that the list is being used as a non-tariff barrier against foreign panels because there are no non-India solar manufacturers on the list.

On the production side, India's government in early 2022 announced a hefty $2.6 billion of funding for its solar PV manufacturing "Production Linked Incentive" (PLI) scheme. That added to the $617 million of funding already directed to the program. The program provides subsidies to companies that build large PV manufacturing plants in India.

The combined tariff and production incentive program will produce an additional 40 GW of cell and module production capacity, according to Indian rating company ICRA, a Moody's Investors Services company. That would go a long way towards making India self-sufficient in solar production and allow the country to meet the massive domestic demand for solar products.

Japan's solar slows but much of the rest of Asia/Pacific is soaring

Solar installs in Japan in 2021 fell by -25% to 6.5 GW, reversing most of the +28% surge seen in 2020 to a 5-year high of 8.7 GW, according to BNEF. Japan's solar installs in 2022 will fall by another -24% to 5.0 GW in 2022, stabilize in the 4-5 GW area during 2023-25, and then resume solid growth during 2026-2030, according to forecasts by BNEF.

Japan's solar growth is currently slowing due to the phase-out of some subsidies. Yet, the Japanese government's subsidy support for solar will continue in the coming years. The government's FIT (feed-in tariff) program will continue to support smaller-scale solar projects and the government in April 2022 launched a new feed-in-premium (FIP) support program for large-scale projects.

The new FIP program will provide solar electricity producers a premium over wholesale electricity prices as an incentive, as opposed to the old FIT system that specified a fixed electricity price. The goal of the new system is to transition the Japanese solar market to unsubsidized parity.

Aside from subsidies, the Japanese government is pursuing aggressive solar targets and is relying on solar to meet its emissions goals. In July 2021, the Japanese government almost doubled its solar target to a cumulative capacity of 108 GW by 2030. In order to meet that target, Japan would need to install 37 GW of solar by 2030, or roughly 4 GW per year. The government raised its solar target to help meet Japan's carbon target of cutting greenhouse gas emissions by 46% by 2030 from 2013 levels.

Solar in Japan should also see support in coming years from Japanese corporations looking to sign 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/Pacific, Taiwan is expected to see strong solar installs in the coming years as the government promotes solar to meet its climate goals. Solar installs in Taiwan in 2021 fell by -4% to 1.6 GW, pausing after extraordinary growth rates of +109% in 2018, +91% in 2018, +41% in 2019, and +18% in 2020, according to BNEF. Taiwan's solar installs will show strong growth in 2022 of +28% to 2.1 GW, 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 plants in order to meet its goal of net zero emissions by 2050.

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 a compounded annual growth rate of 35% in the 5-year period through 2021. In 2020, South Korea's solar installs surged by +51% to a record 5.6 GW, although installs in 2021 then fell by -26% to 4.1 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

SOLAR PV GROWTH OUTLOOK (CONTINUED)

25% from 10% for the amount of annual renewable energy that electric utilities must source by 2030.

In Australia, solar installs in 2021 grew sharply by +25% to 4.7 GW, capping a 5-year compounded annual growth rate of 39% seen during 2016-21, according to BNEF. Australia's solar installs in 2022 will grow by +5% to 4.9 GW, according to BNEF.

SOLAR PV ANNUAL NEW INSTALLATIONS

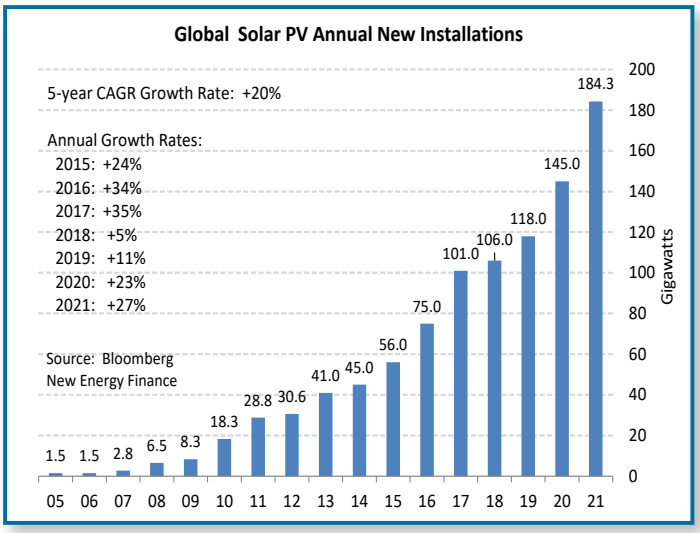
New global solar PV installations in 2021 grew by +27% yr/yr to a record 184 gigawatts (GW), according to Bloomberg New Energy Finance (BNEF). Solar growth in 2021 was even stronger than the +23% growth rate seen in 2020. Solar growth in 2020-21 defied the pandemic lockdowns and supply disruptions and nevertheless rose to new record levels. Global solar installations have grown by a compounded annual rate of +20% over the last 5 years and have risen by 10-fold from 2010.

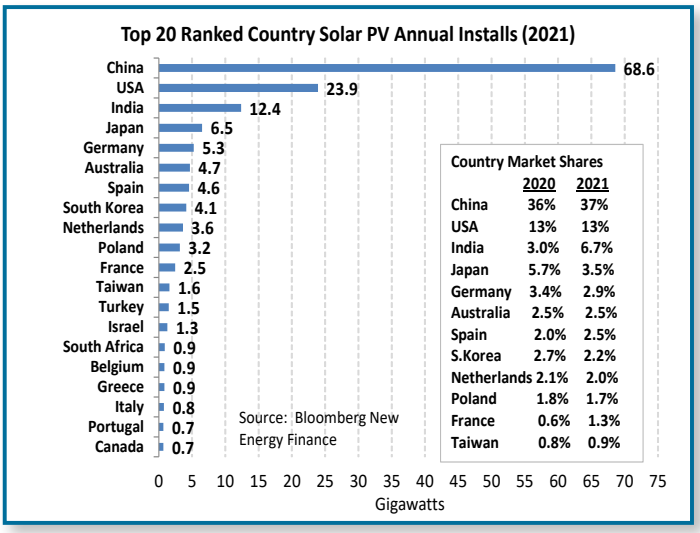
In 2021, China led the world for annual new solar installs for the ninth straight year with a record 69 GW of installs, up 32% yr/yr, according to BNEF. The U.S. had another big year in 2021 with +28% yr/yr growth to 23.9 GW, maintaining its second-place position for the most annual installs. India in 2021 jumped into third place from fifth place, with 192% yr/yr growth to 12.4 GW. Japan fell to fourth place from third place, with a -24% decline in growth to 6.5 GW from 8.7 GW in 2020. Germany slipped into fifth place from fourth place with +8% growth to 5.3 GW.

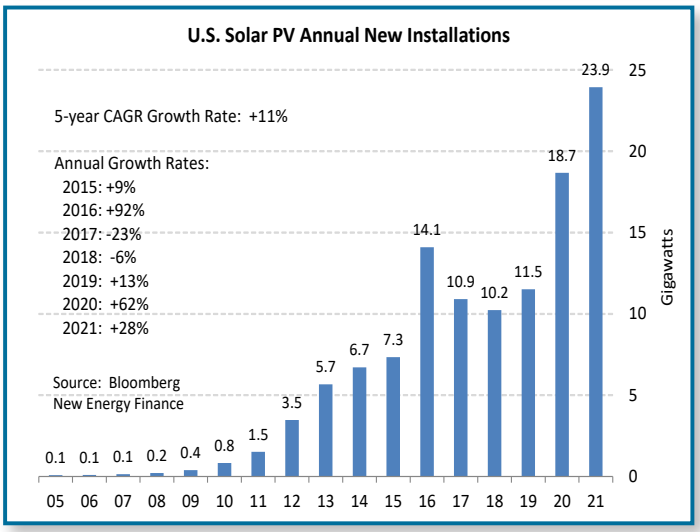
There were 14 countries in 2021 with installs above 1 GW, more than the 7 such countries seen as recently as 2017. The global spread of solar illustrates how the industry is becoming more diversified and less dependent on growth rates in a few countries. Fitch forecasts that 36 nations will install more than 1 GW of solar by 2029.

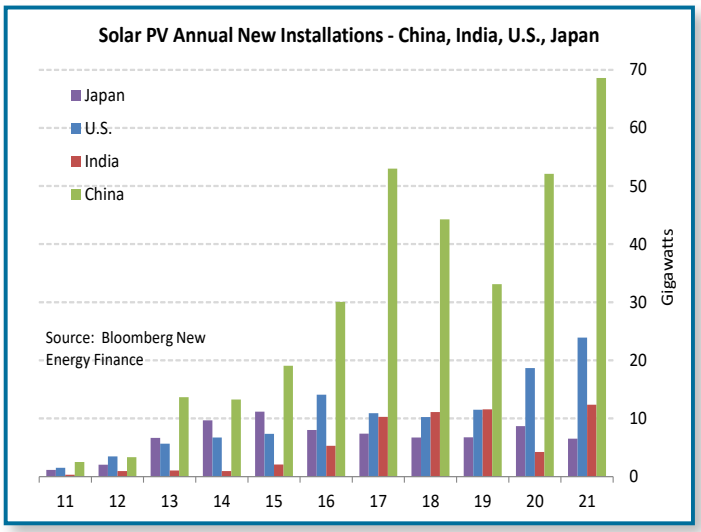
Solar growth in Europe in 2021 grew sharply by +29% yr/yr. The largest PV install amounts were in Germany with 5.3 GW (+8% yr/yr), Spain 4.6 GW (+50%), Netherlands 3.6 GW (+4%), and France 2.5 GW (+154%), according to BNEF.

U.S. solar PV installations in the five years through 2021 grew at a compounded annual rate of +11% and rose 29-fold from 2010, according to BNEF. The states with the largest amount of new PV solar installations in 2021 were Texas with 6.1 GW (+77% yr/yr), California 3.6 GW (-7%), Florida 1.7 GW (-41%), Virginia 1.5 GW (+3%), Georgia 1.2 GW (+103%), and Indiana 1.1 GW (+1630%), according to Wood Mackenzie.









SOLAR PV CUMULATIVE INSTALLATIONS

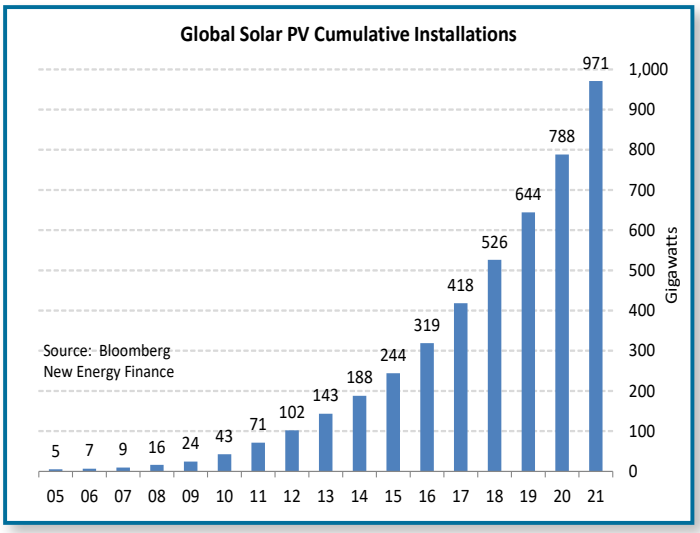
The amount of cumulative PV electricity generation capacity across the world in 2021 grew sharply by +23% yr/yr to 971 GW, according to Bloomberg New Energy Finance (BNEF). In the last five years, global cumulative solar PV electricity generation capacity increased by more than 3-fold from 319 GW in 2016 to 971 GW in 2021, representing a compounded annual growth rate of +25%.

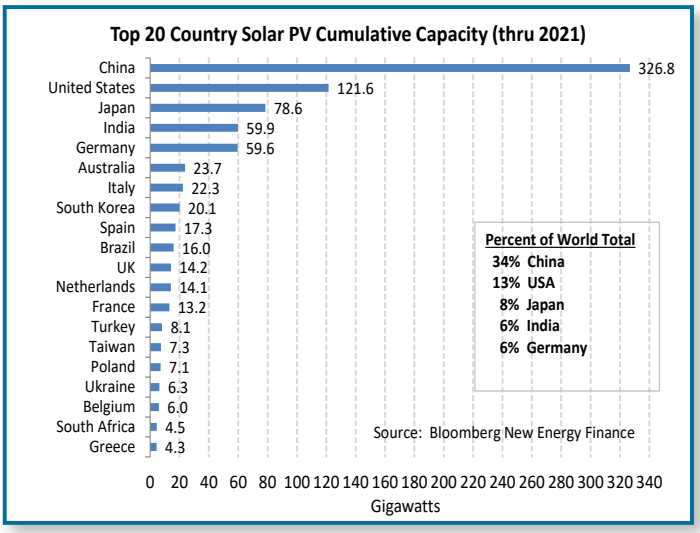
China in 2021 continued to be the world's leader for cumulative solar capacity at 327 GW, according to BNEF. China at the end of 2021 accounted for 34% of the world's solar PV capacity. In the past five years, China's cumulative installed solar capacity soared by 4-fold from 82 GW in 2016 to the 2021 level of 327 GW, representing a 5-year compounded annual growth rate of +32%.

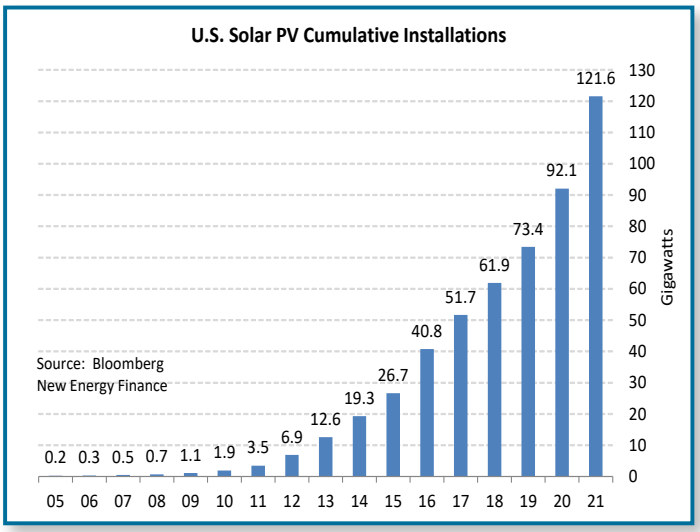
The U.S. in 2021 remained in second place for cumulative solar installs. U.S. solar electricity capacity in 2021 rose by +32% to 122 GW, representing 13% of world capacity. Over the past five years, U.S. cumulative solar electricity capacity rose by more than 3-fold to 122 GW from 41 GW in 2016 and showed a compounded annual growth rate of +24%.

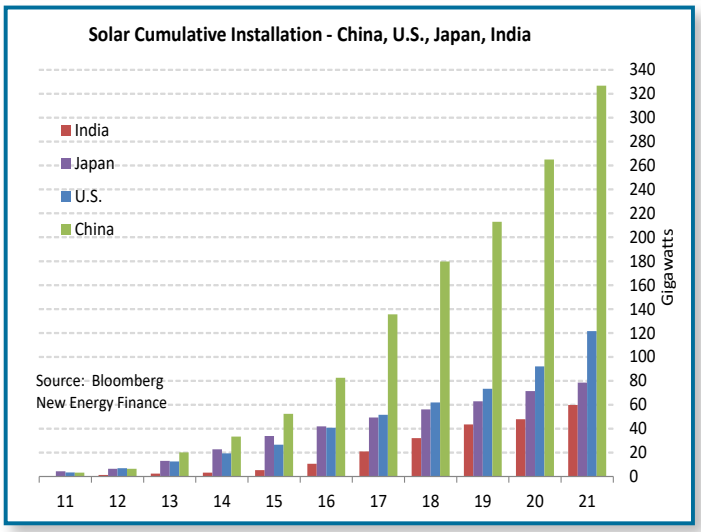
Japan remained in third place for the eighth straight year. Japan's cumulative solar capacity in 2021 rose by +10% to 79 GW, representing 9% of world capacity. Japan's cumulative solar capacity in the past five years has risen by nearly 2-fold to 79 GW from 42 GW in 2016, representing a 5-year compounded annual growth rate of +13%.

India in 2021 overtook Germany for fourth place with 60 GW of cumulative solar PV capacity, up +25% yr/yr. India's cumulative solar capacity in the past five years has risen more than 5-fold to 60 GW from 11 GW in 2016. India, at the end of 2021, accounted for 6% of the world's total solar PV capacity.









LEVELIZED COST OF SOLAR ELECTRICITY

Solar's electricity cost falls -3% 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 as of late-2021 fell by -3% yr/yr to a midpoint of $35.5 per MWh ($30-41 range) on an unsubsidized basis, according to Lazard in the latest annual edition of its comprehensive "Levelized Cost of Energy Analysis-Version 15.0" released in October 2021. That added to the declines of -7% in 2020, -7% in 2019, and -14% 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 -8% 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 2021 fell by -4% yr/yr for Community Solar to $75.0/MWh ($59-91 range) and -1% yr/yr for Rooftop Residential to $184/MWh ($147-221). The mid-point LCOE for Rooftop Commercial and Industrial fell by -2% to $123.5/MWh ($67-180 range).

The Lazard report found that the mid-point cost for utility-scale crystalline solar PV of $35.5/MWh is now 67% cheaper than the $108.5/MWh mid-point cost for newly-built coal plants, 79% cheaper than the $167.5/MWh mid-point cost for nuclear plants, 80% cheaper than the $173.5/MWh mid-point cost for gas-peaking plants, and 38% cheaper than the mid-point cost of $59.5/MWh for natural gas plants.

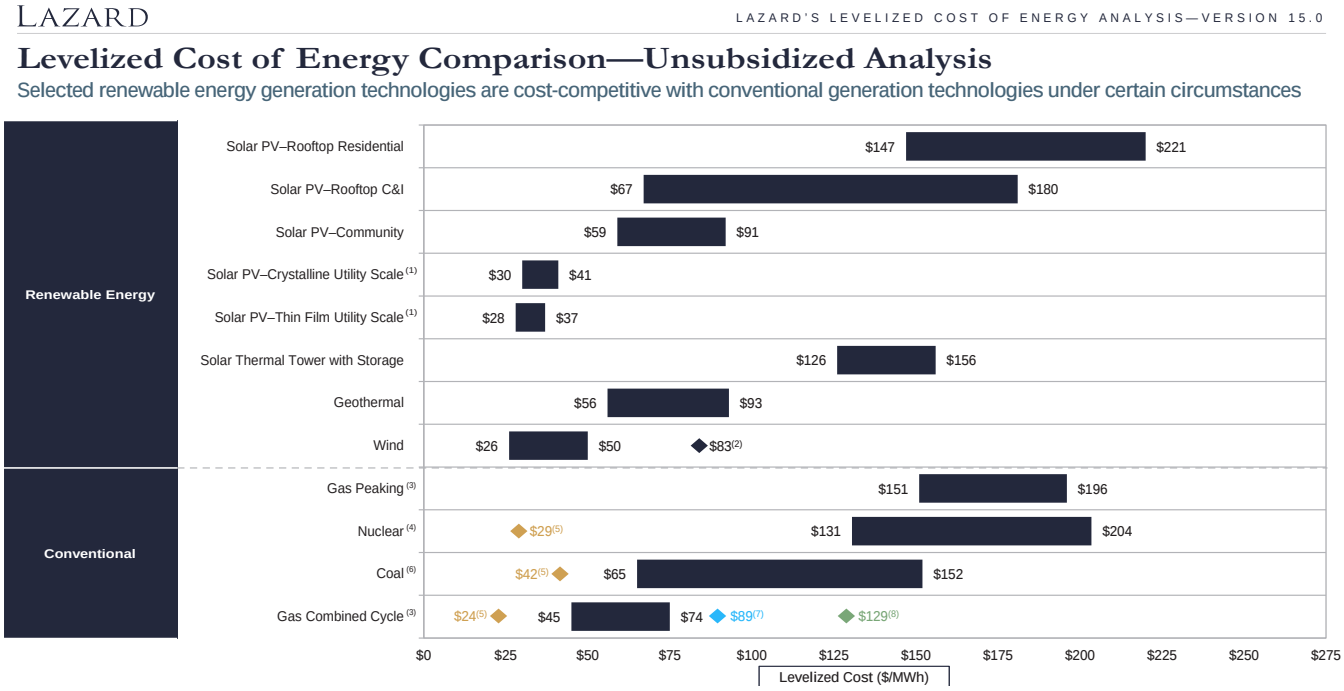
The Lazard data shows that, on average, it is no longer economical for a utility to build any new coal, nuclear, or natural gas plants, relative to solar or wind.

Moreover, solar has become so inexpensive that it is now cheaper to build a brand new PV utility-scale solar plant from scratch for $35.5/MWh than it is to keep an existing coal plant running at a marginal cost of $42/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 $24/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.[1]

1 BNEF, "The First Phase of the Transition is about Electricity, 1/28/2020.



Source: Lazard's Levelized Cost of Energy Analysis - October 2021, Version 15.0.

PRICING - SOLAR MODULES, CELLS, AND POLYSILICON

Solar module prices have edged higher 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 risen to the current level of 20.5 cents, according to PV Insights. Since 2010, silicon module prices have plunged by a total of -87%.

The price of thin-film modules fell to a record low of 20.7 cents per watt in July 2020 but is currently mildly above that level at 22.6 cents, according to PV Insights. Since 2010, thin-film module prices have plunged by a total of -83%.

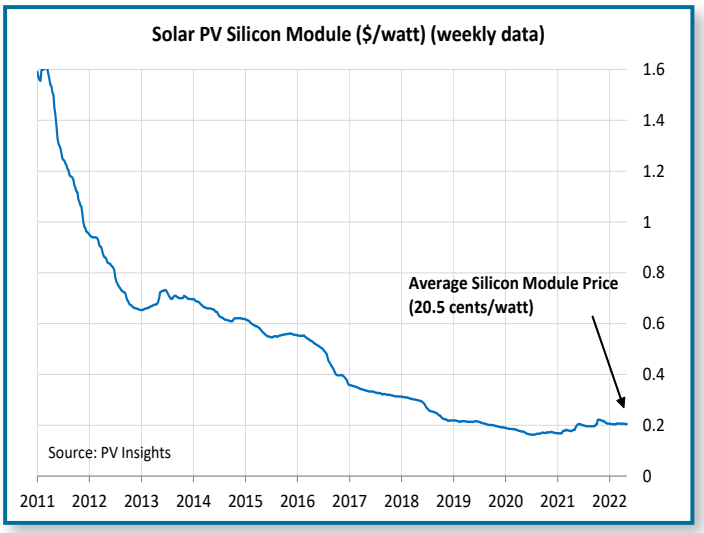
Solar module prices have risen in the past year due to strong demand, higher polysilicon input prices, higher costs for other materials, and high shipping costs.

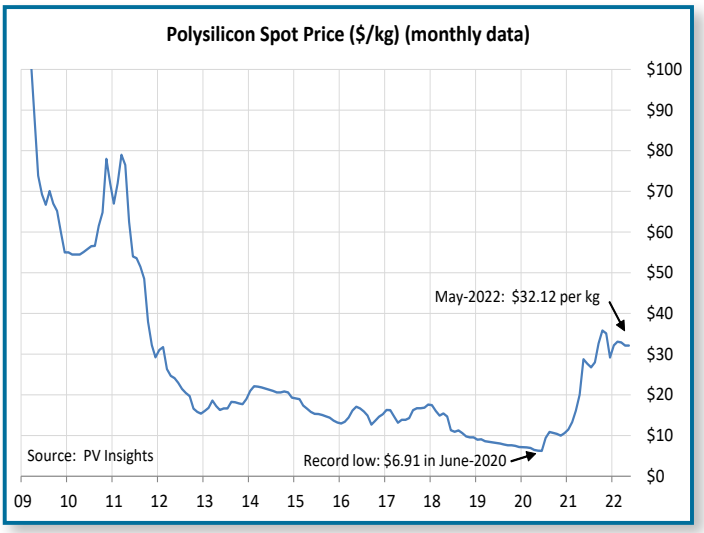
Spot polysilicon prices fell to a record low of $6.90 per kg in May 2020. Polysilicon prices then spiked higher to a 10-year high of $35.81 in October 2021 but have since eased to $32.12, according to PV Insights. Despite the recent volatility, polysilicon prices are still down by -55% since 2010.

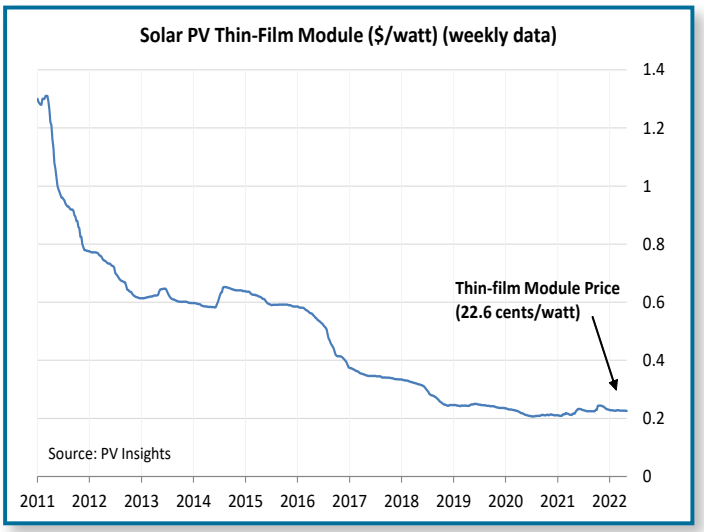
Polysilicon prices fell to a record low during the worst of the pandemic shutdowns in spring 2020, but then rebounded higher after several polysilicon manufacturers were forced to temporarily close down their plants due to disruptions such as fires and flooding. Polysilicon prices have also risen as solar wafer and cell producers try to avoid polysilicon from the Xinjiang province due to U.S. import restrictions. Polysilicon prices have also seen strength due to strong demand.

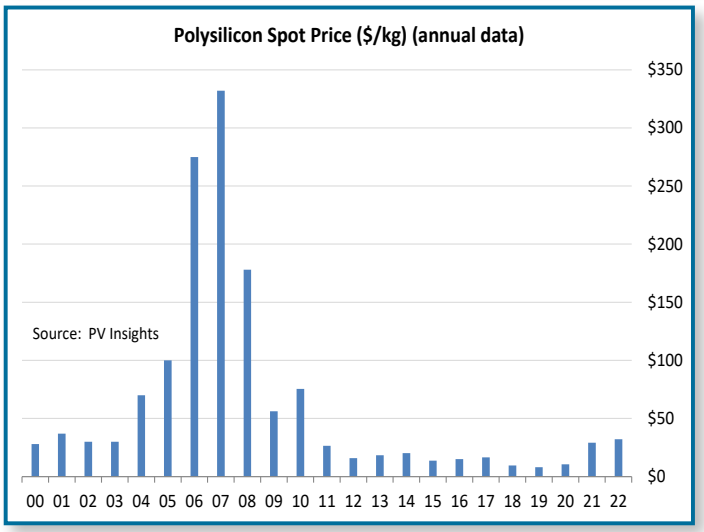
Polysilicon prices should ease over the next few years due to the large number of new polysilicon factories that have been announced.

Historically, solar pricing has seen steady downward pressure due to technology advancements and manufacturing economies of scale, a trend that should resume once pandemic and trade-related problems ease and new capacity comes online.









SOLAR JOBS

U.S. solar jobs in 2020 fell by -6.7% to 231,474 from 248,034 in 2019, according to the "National Solar Jobs Census 2020" published by The Solar Foundation in May 2021. Solar jobs fell in 2020 due to pandemic disruptions and were well below the record high of 260,077 jobs seen in 2016.

Despite the drop in 2020, the U.S. solar industry during the 10-year period of 2010-2020 added a net total of 137,972 jobs to the U.S. economy, rising by a total of +148% over that period.

Solar employment in the ten years through 2020 grew five 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 the U.S. substantially exceed those in the fossil fuel industries. Specifically, the 231,474 jobs in the solar sector far exceed the 139,500 direct jobs in the oil/gas extraction industry and 42,200 direct jobs in the coal mining industry at the end of 2020, according to figures from the U.S. Bureau of Labor Statistics (see chart on the right).

Globally, solar PV is a huge employer, with 3.98 million solar jobs worldwide at the end of 2020, up by +6% from 3.75 million at the end of 2019, according to the " Renewable Energy and Jobs--Annual Review 2021" from the International Renewable Energy Agency (IRENA).

China is far ahead of the U.S. in solar PV jobs, with a total of 2.3 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 220,000 jobs, the EU with 194,000 jobs, and India with 163,500 jobs, according to IRENA.