

SOLAR SECTOR UPDATE

MAC Global Solar Energy Stock Index (SUNIDX) is licensed as the tracking index for the U.S.-based Invesco Solar ETF* (NYSE ARCA: TAN) and European-based Invesco Solar Energy UCITS ETF* (London: ISUN LN & RAYS LN) (Xetra: SOLR GY) (Borsa Italiana: SOLR IM) (Swiss: SOLR SW).

Note: Index performance does not reflect transaction costs, fees or expenses of the Invesco ETFs.

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MAC Global Solar Energy Index (SUNIDX)



Solar stocks dip but valuation is inexpensive and global solar demand is very strong

The MAC Global Solar Energy Stock Index in 2023 is down by -26% on a year-to-date basis. The MAC Solar Index saw extraordinary gains of +67% in 2019 and +245% in 2020, but then settled back by -26% in 2021 and -5% in 2022.

The MAC Solar Index is 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).

Solar stocks have recently been undercut by a drop in polysilicon prices and the decline in solar module prices to a record low as new production capacity comes online and as pandemic supply chain disruptions subside.

That price decline has been a negative factor for the profit margins of manufacturers of polysilicon, wafers, cells, and modules, although those manufacturers constitute only about 30% of the total weight in the MAC Solar Index. The other 70% of the Index weight is in installers and operators of solar systems, or

manufacturers of non-module solar components such as inverters, solar glass, and solar trackers.

The good news is that the decline in solar prices should benefit the solar industry over the longer-run by boosting solar demand and unit sales as solar becomes even more competitive against alternatives. The decline in solar costs is already a boon for developers and installers of solar plants, who can buy solar panels at cheaper prices and should see a significant increase in project demand from utilities, corporations, and households.

Separately, U.S. solar stocks have been undercut by the shortage of solar panels available for U.S. solar installers. This shortage has been caused by geopolitical factors as the U.S. government imposes duties on Chinese solar modules and blocks the import of some solar products from the Chinese province of Xinjiang. The U.S. solar sector has been able to largely work around these import constraints, but there are still not enough panels to meet extraordinary U.S. solar demand.

The recent decline in solar stocks has left the MAC Solar Index with a valuation that is far cheaper than that of the broad indexes. The MAC Solar Index has a P/E of 11.8 (vs the S&P 500's 19.7 and the Nasdaq 100's 29.2), an estimated P/E of 14.8 (SPX 19.5, NDX 26.0), price-to-book of 1.26 (SPX 4.1, NDX 7.2), and price-to-sales of 1.2 (SPX 2.4, NDX 4.5), according to Bloomberg data.

In any case, the U.S. is on the cusp of a boom in solar installs and manufacturing as companies take advantage of the tax subsidies contained in the Inflation Reduction Act (IRA). That law offers a massive 10-year tax subsidy for both the installation and manufacture of solar products. The new law has led to the announcement so far of 51 new or expanded solar manufacturing facilities in the United States, according to the SEIA. The U.S. IRA has also sparked subsidy competition from Europe, Asia-Pacific, and Canada, who don't want to fall behind in the solar race.

Despite the recent factors holding back solar stocks, the global solar industry is booming with Bloomberg New Energy Finance (BNEF) forecasting blockbuster solar install growth for 2023 of +56% yr/yr, adding to last year's growth of +39% yr/yr.

SOLAR PV GROWTH OUTLOOK

The global solar industry in 2022 grew sharply by +39% yr/yr to a record 252 GW, according to Bloomberg New Energy Finance (BNEF), the fourth consecutive year of double-digit growth.

During the 5-year period of 2017-2022, solar installs showed a compounded annual growth rate of +20%, making it one of the highest sustained-growth industries in the world.

BNEF is forecasting that solar will continue to show strong growth in the coming years. BNEF is forecasting +56% growth in 2023 and a compounded annual growth rate of +19% over the 5-year period through 2028. For 2030, BNEF is forecasting 707 GW of annual installs, which is 2.8 times the current install level.

Demand for solar has soared in recent years as solar becomes cheaper than its competitors, and as nations and corporations race to meet their net zero emissions targets. Many countries, especially in Europe, are also taking energy security very seriously and are focused on building domestic electricity infrastructure such as solar to reduce their reliance on foreign oil and natural gas.

The long-term outlook for solar looks very bright. There will be a massive \$4.2 trillion of spending on solar equipment through 2050, according to BNEF's 2020 New Energy Outlook. BNEF also forecasts that photovoltaic (PV) solar will account for 38% of world electricity capacity by 2050, up sharply from the 2019 world level of 11%.

"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 is expected to surge in the coming years as solar costs decline, and solar becomes even more competitive against fossil fuels and nuclear. BNEF has determined that solar and wind are now the cheapest sources of new electricity generation in countries accounting for 82% of the world's power supply.

Bullish longer-term factors for solar stocks include (1) the global dash to reduce carbon emissions as many countries have adopted net zero emissions goals to add to their Paris climate agreement goals, (2) strong demand for solar by many global corporations

that have 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 need for many nations to improve their energy security by building domestic electricity infrastructure such as solar, thus freeing themselves from the risk of importing fossil fuels from hostile areas.

Solar surges in China

Solar is a key industry in China. China needs low-priced solar to expand its electricity capacity to support its aggressive economic growth targets. China also needs solar to build that new electricity generation in a way that reduces China's reliance on coal, improves its air quality, and meets its carbon emission reduction targets. Also, solar is a national champion industry in China with strong support from the government.

China installed a massive 107 GW of solar in 2022, surging +55% yr/yr and adding to the extraordinary growth rates of +57% seen in 2020 and +32% in 2021, according to BNEF.

Solar accounted for 44% of China's new electricity capacity additions in 2022, according to China's National Energy Administration. Solar has the largest share of new electricity capacity in China by far. Fossil fuel electricity (coal, gas, and oil) accounted for only 22% of total Chinese new electricity capacity in 2022, wind accounted for 19%, hydro accounted for 12%, and nuclear and other accounted for 3%, according to the NEA.

China's solar growth is expected to accelerate in 2023. BNEF is forecasting Chinese solar growth of +96% yr/yr in 2023 to 209 GW.

The Chinese government is relying heavily on solar to meet its 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 18% of its electricity from renewable sources (excluding hydro) by 2025. China also has a 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 started in 2021 and is running smoothly, thus leading the government to expand the project. The Chinese government announced another 455 GW of desert solar and wind projects, with 200 GW slated to be built by 2025 and another 255 GW to be built by 2030. The electricity from those plants will primarily be delivered to the

SOLAR PV GROWTH OUTLOOK (CONTINUED)

populated eastern regions of the nation.

Chinese solar growth was strong in 2020-22 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 added benefits to subsidy-free projects, such as a guaranteed price for solar electricity output and priority on the grid. Moreover, 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 grow more predictably with stable profit margins, as opposed to the boom-bust days of the past that were caused by erratic government subsidy policies.

Without subsidy volatility, 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 therefore accelerate, with the solar industry increasingly dominated by large players having the best technology and lowest production costs.

By contrast, the Chinese solar market in previous years was buffeted by erratic subsidy policies that caused upheaval in the industry. For example, Chinese solar installs in 2017 soared by 76% to a then-record high of 53.0 GW as developers took advantage of very generous government subsidies.

In response to that 2017 install surge, however, 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 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 announcement date.

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 demand remains very strong but is still constrained by a panel shortage

U.S. solar growth in 2022 fell by -3.6% to 23.6 GW from the record high of 24.5 GW posted in 2021, according to BNEF.

Despite the decline in annual installs, the 23.6 GW of solar that was installed in 2022 meant that solar accounted for 4.74% of total U.S. electricity generation in 2022, up from a 3.95% share in 2021, according to the U.S. Energy Information Administration (EIA).

Solar accounted for 50% of all new U.S. electricity-generating capacity in 2022, marking the fourth consecutive year that solar took first place, according to SEIA/Wood Mackenzie. Solar was far ahead of a 23% share of total new electricity generation for wind, and a 17% share for natural gas.

U.S. residential installs in 2022 soared by +40% yr/yr to 6 GW, with a record 700,000 homeowners installing solar, according to SEIA/Wood Mackenzie. The residential sector was able to partially sidestep import constraints since that sector sources up to half of its panels from domestic U.S. manufacturers.

Meanwhile, the U.S. utility and commercial sectors saw strong solar demand but were unable to meet that demand because of a panel shortage, thus causing the decline in the overall U.S. solar install rate.

Specifically, (1) utility solar in 2022 fell by -31% yr/yr to 11.8 GW, (2) commercial solar (i.e., distributed solar projects for commercial, industrial, agricultural, school, government, and non-profit off-takers) fell -6% yr/yr to 1.4 GW, and (3) community solar fell -16% yr/yr to 1.0 GW, according to SEIA/Wood Mackenzie.

The shortage of solar panels in 2022 was caused by U.S. government tariffs and import restrictions. The U.S. currently manufactures very few solar panels and relies on imports to meet the bulk of its solar panel needs. This will change as U.S. solar production ramps up from the incentives provided by the Inflation Reduction Act. But in the meantime, U.S. solar developers have been hamstrung in meeting demand.

Still, the consensus is that U.S. solar installs will soar over the next several years as import restrictions are overcome and as U.S. solar panel manufacturing ramps up, thus providing a steady supply of panels to meet very strong demand.

BNEF is predicting that U.S. solar installs will surge by +43% yr/yr in 2023 and +14% in 2024. By 2030, BNEF is predicting that annual U.S. solar installs will more than double to 54 GW from 24 GW in 2022.

U.S. tariffs cause shortage of solar panels -- U.S. solar installs stalled in early 2022 mainly because of the tariff investigation by the U.S. Department of Commerce (DOC), which restricted the number of solar panels available to U.S. solar developers.

Specifically, the DOC, on March 25, 2022, opened an investigation into whether some Chinese companies were circumventing the decade-old anti-dumping and countervailing (AD/CVD) tariffs with their factories in Malaysia, Thailand, Vietnam, and Cambodia. As of late 2021, those countries accounted for about 80% of the \$7 billion worth of solar cell and module products that the U.S. imported annually, according to Bloomberg.

SOLAR PV GROWTH OUTLOOK (CONTINUED)

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

However, President Biden, on June 6, 2022, provided some relief from the tariff investigation by announcing a 2-year waiver of any tariffs that might be imposed as a result of the DOC investigation. That move gave the solar industry a 2-year window through June 2024 to buy panels without fear of tariffs.

From a legal standpoint, the Biden administration could not halt or directly interfere with the DOC's quasi-judicial tariff investigation. Nevertheless, the Biden administration found a way to nullify the investigation for at least two years with the tariff waiver.

In August 2023, the DOC issued its final ruling that some manufacturers in southeast Asia were, in fact, circumventing the Chinese tariffs by using Chinese components. The DOC announced that those companies would be hit with import tariffs after the 2-year waiver expires in June 2024.

In some good news about the ruling, however, the DOC said some companies in Southeast Asia were not circumventing duties, and those companies will be able to export their solar products to the U.S. without any penalty tariffs. Also, the DOC said that companies that make silicon wafers in Southeast Asia will not be subject to the tariff even if they use Chinese polysilicon, which was a big break for the solar industry.

Despite the DOC's final tariff ruling, no penalty tariffs will be collected until June 2024 at the earliest because of President Biden's tariff waiver. Also, the duties will not be applied retroactively to modules purchased prior to the waiver expiration in June 2024. There is also the possibility that President Biden might extend the tariff waiver beyond 2024.

In any case, U.S. solar importers by 2024 will have had enough time to find work-arounds. The duties are not expected to prevent the U.S. from finding enough panels to meet strong demand.

In the bigger picture, it is important to note that the U.S. solar market represented only 9% of global solar installs in 2022. If the U.S. government blocks certain panels from being imported into the U.S. with tariffs, those panels will quickly be snapped up by buyers in many other countries where demand is booming, meaning the overall global solar install rate is likely to see only a minor impact from the U.S. tariff ruling.

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

Regarding the history of the U.S. 201 tariffs, then-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 until 2026.

Xinjiang restrictions also disrupt U.S. solar panel supply -- U.S. solar installs and imports have also been disrupted by the U.S. government's action to block some solar imports from the Xinjiang region of China due to allegations of forced labor at some companies located in Xinjiang. However, that situation is being resolved as solar companies meet U.S. government documentation requirements and acquire the panels they need elsewhere.

The Xinjiang issue began for the solar industry when 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 that the companies were associated with government-run forced labor programs of the Uyghur Muslim minority. China's government denied the forced-labor allegations and objected to what it said was U.S. interference in its internal affairs.

The targeted companies were hamstrung in trying to defend themselves against the forced-labor allegations by China's Anti-Foreign Sanctions Law, which makes it illegal for Chinese companies to comply with U.S. requirements to avoid sanctions. The Chinese law makes it difficult for Chinese companies to respond to allegations of using forced labor without getting themselves into hot water with the Chinese government, putting them in a Catch-22 situation caused partly by U.S.-Chinese geopolitical tensions.

Going beyond the initial Withhold Release Order, the U.S. Congress in December 2021 then passed the Uyghur Forced Labor Prevention Act (UFLPA), which was signed into law by President Biden and took effect on June 21, 2022. That law bans the import into the U.S. of products made in Xinjiang unless the importer can provide convincing evidence that the products were not made with forced labor. The UFLPA does not impose a total

SOLAR PV GROWTH OUTLOOK (CONTINUED)

ban on importing goods from Xinjiang, but rather imposes only a "rebuttable presumption" of a ban that can be overcome with proper documentation.

The Xinjiang restrictions were significant for the global solar industry because factories in the Xinjiang region produced about 45% of the world's solar-grade polysilicon as of 2020, according to Bernreuter Research. Factories in Xinjiang do not assemble any significant number of solar panels, but they do produce a significant amount of polysilicon.

However, there has been a sharp increase in number of polysilicon factories built outside Xinjiang. Wood Mackenzie projects that less than one-quarter of the world's polysilicon will come from Xinjiang factories in 2023.

The global solar industry has also adjusted to the Xinjiang labor issues by creating better supply chain documentation. U.S. and global solar companies have been aware of the Xinjiang risk for the last several years. They have already aggressively taken steps to divert supplies away from Xinjiang and do a better job of ensuring transparency and documenting their supply chains to allow the importation of panels into the United States.

Also, 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"](#)).

The U.S. ban on importing undocumented solar products from Xinjiang has caused some supply-chain disruptions for U.S. solar developers, who have had shipments 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 decade-long U.S. tariffs on Chinese solar products.

U.S. module imports have recently soared, suggesting that the Xinjiang restrictions are no longer causing major problems. In Q2-2023, U.S. import of solar panels soared by +91% yr/yr, according to Panjiva, the supply chain research unit of S&P Global Market Intelligence. During the calendar year 2022, U.S. solar module imports rose by 48% yr/yr to \$9.3 billion, with over 40% of those annual imports occurring in Q4 as modules were released from earlier detainment.

Europe is also taking steps to block products that are tied to forced labor. The European Commission in September 2022 proposed a Forced Labor Products Ban bill, which applies to forced-labor

products manufactured anywhere in the world, including within Europe itself. However, the European forced-labor bill may not have much near-term impact because it still needs to be approved by the European Parliament and isn't expected to go into effect for up to two years after approval.

U.S. solar set to boom due to IRA solar stimulus -- The U.S. solar industry received a huge boost in August 2022 when Congress passed, and President Biden signed, a \$369 billion climate bill, representing the single biggest climate investment in U.S. history. The bill was named the "Inflation Reduction Act" since it was partly designed to reduce healthcare and energy costs for consumers.

According to independent estimates by various climate research groups, the bill may double the speed at which the U.S. is cutting carbon emissions and may result in a 40% emissions cut through 2030. That would go a long way towards meeting President Biden's goal of a 50-52% emissions cut by 2030.

The energy provisions of the Inflation Reduction Act raised the solar investment tax credit (ITC) to 30% from 26%, and implemented a 10-year extension of the 30% ITC tax credit through 2032, with step-downs to 26% in 2033 and 22% in 2034. The ITC also has "adders" that can boost the ITC to as much as 50%, including credits for paying "prevailing wages," creating apprenticeship programs, using solar panels produced in the U.S., and siting solar projects in brownfield sites traditionally linked to fossil fuels such as coal.

Also, the ITC now has a "direct pay" provision. This allows developers without sufficient tax liabilities to claim a direct payment from the federal government in the form of a tax rebate, which is much more valuable to the solar industry than the old system, which required equity investors with sufficient tax liabilities to claim the ITC credit. Previously, a shortage of tax equity limited the ability of the solar industry to take full advantage of ITC credits.

The solar industry now has a decade of ITC certainty for project development. Previously, the U.S. solar market went through various booms and busts as developers tried to stay ahead of short-term ITC windows and step-downs.

Before the Inflation Reduction Act was passed, the solar industry was operating under the legislation in the pandemic aid bill passed in December 2020, whereby the ITC was set at 26% for 2020 and 2021, with a step-down to 22% in 2023. For 2024, the ITC under the previous law would have fallen to 10% indefinitely for large-scale solar projects and to zero for small-scale solar projects.

The Inflation Reduction Act also established an ITC for battery storage for the first time, giving solar-plus-storage a big boost.

The Inflation Reduction Act also provided a big boost for residential solar by providing a 30% tax credit for residential solar

SOLAR PV GROWTH OUTLOOK (CONTINUED)

systems installed from 2022 through 2032, with a step-down to 26% in 2033 and 22% in 2034. The new credit also applies to residential battery storage systems installed in conjunction with a solar system. The previous residential tax credit was set at 26% for 2022 and 22% in 2023 before ending in 2024, and did not include battery storage systems.

To support U.S. domestic solar production, the Inflation Reduction Act also provided \$30 billion to implement a new production tax credit (PTC) for U.S. solar manufacturers through 2035. The solar PTC will help the U.S. build a larger solar manufacturing base and reduce its reliance on imported solar panels.

Manufacturing tax credits are specified for solar products built in U.S.-based facilities, such as modules, thin-film or crystalline PV cells, wafers, backsheets, and solar-grade polysilicon. There is also a manufacturing tax credit for DC-to-AC inverters, which has prompted some inverter companies, such as Enphase, to announce they will build new manufacturing plants in the United States.

TD Cowan is forecasting that the IRA manufacturing incentives will result in domestic U.S. solar manufacturing capacity surging by more than six times to 45 GW by the late-2020's from the U.S. capacity of only 7 GW in 2021 (see TD Cowan, "Can the Sun Shine on US Solar Manufacturing?" March 2023).

TD Cowan estimates that the U.S. by the late-2020s could manufacture enough solar panels to meet virtually all its projected demand of around 45 GW. That would be a huge improvement from the fact that the U.S. in 2021 manufactured only about 7 GW of solar panels, satisfying less than one-third of installs in that year and forcing developers to import the remaining two-thirds of solar panels.

The IRA's ITC and production credits have led to a surge of announcements by various global solar companies about their plans to build new factories in the United States. Solar plant announcements have come from First Solar, Moxone, NexTracker, SolarEdge, Enphase, Canadian Solar, Hanwha Q Cells, Meyer Berger, Enel, Waaree Energies, JA Solar, and others. More solar plant announcements are likely from other companies in the coming months as the Treasury releases additional guidance on various IRA provisions.

In the year since the IRA was passed, companies have announced the new construction or expansion of 51 solar manufacturing facilities, with \$20 billion of new solar and storage investments, according to the Solar Energy Industries Association (SEIA.org).

Specifically, the IRA has sparked a total of 155 GW of new solar manufacturing capacity, including 85 GW of solar modules, 43 GW of solar cells, 20 GW of silicon ingots and wafers, and 6.8 GW of inverters, according to the SEIA. The IRA has also led to the announcement of 14 new standalone energy storage

manufacturing facilities, which will allow the U.S. to install more solar-plus-storage electricity generation sites.

Over the next decade, the SEIA is expecting 475,000 solar energy jobs, \$565 billion of private sector investment, and enough solar capacity to power every home east of the Mississippi River.

The U.S. solar industry no longer needs any subsidy help from the U.S. government since solar is now the cheapest form of new utility-level electricity capacity on an unsubsidized basis and is self-sustaining without any subsidies. Nevertheless, the new policy support from the U.S. government will give the solar industry a huge extra boost.

The solar industry was ecstatic about Washington's passage of the Inflation Reduction Act. The Solar Energy Industries Association called the new law "a massive catalyst for the solar industry." Wood Mackenzie responded to the new law by raising its forecast for U.S. solar growth by 40% for the five years through 2027.

JPMorgan Chase analyst Mark Strouse called the climate legislation "the largest policy change in U.S. history to accelerate growth in what we have viewed as an already inevitable energy transition to renewables."

The surge in U.S. policy support for solar has put other governments on notice that they need to boost their own policy support or see the U.S. win the lion's share of new solar manufacturing production outside China in the coming years. Since the U.S. passed the IRA, countries that have boosted their subsidy support for solar include EU countries, Canada, and South Korea, among others.

Other U.S. solar policy support -- Elsewhere on the solar policy front, President Biden, on June 6, 2022, took executive action by announcing that the administration would invoke the Cold War-era Defense Production Act to gain greater powers to support U.S. solar manufacturing.

An executive from the Solar Energy Industries Association (SEIA) noted that the Biden administration's increased powers under the Defense Production Act "can be used to drive federal procurement, establish project labor agreements, community benefit agreements and master support agreements, develop loan programs, create partnerships and establish other programs that address the emergency need for clean energy."

The invocation of the Defense Production Act gives the U.S. Energy Department increased latitude to make loans to U.S. manufacturing companies for the purpose of building domestic solar plants. Under that authority, the Energy Department has already announced a \$56 million program to reduce U.S. dependence on imported solar modules by supporting R&D for non-silicon thin-film solar and perovskite solar cells.

Under the Defense Production Act, the Biden administration is also

SOLAR PV GROWTH OUTLOOK (CONTINUED)

boosting the ability of the federal government to directly purchase domestically-produced solar panels by applying domestic content standards.

Early in his term that began in January 2021, President Biden took a number of executive actions on the climate front. On his first day in office, President Biden 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 less than 1.5 degrees Celsius. President Biden also pledged to reach a 100% carbon-free electricity sector by 2035 and reach net-zero greenhouse gas emissions by 2050.

The Biden administration, in April 2021, announced a new "Nationally Determined Contribution" (NDC) 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 then-President Obama of a 26-28% cut in greenhouse gas emissions by 2025 from 2005 levels. The Biden 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. That order also directs the U.S. government to achieve 100% carbon pollution-free electricity by 2030, which is only eight years away.

The White House explained the order: "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 installs in 2022 grew sharply by +47% yr/yr to a record 41.4 GW, according to industry association SolarPower Europe. That added to the sharp +34% yr/yr increase seen in 2021.

Solar power's share of total electricity generation in Europe rose to 7.3% from 5.7% in 2021, according to SolarPower Europe.

European countries with the largest solar installs in 2022 were Germany (7.9 GW), Spain (7.5 GW), Poland (4.9 GW), the Netherlands (4 GW), and France (2.7 GW), according to SolarPower Europe.

SolarPower Europe is predicting that solar installs in 2023 will

remain strong with growth of +29% yr/yr to 54 GW.

European solar growth has soared in recent years after Europe, in late 2018, scrapped its previous reliance on tariffs and a minimum import price (MIP) scheme that sought to protect domestic solar manufacturers but instead made reasonably priced solar panels unavailable to solar developers. European solar growth has since soared, although Europe is importing about 90% of its panels to meet demand.

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 much of Europe. As a result, 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, which has 1 trillion euros of funding to help EU countries meet their emission-reduction goals under the Paris climate accord.

European solar growth is expected to show solid growth in the coming years due to the need to meet the EU's renewable energy targets. In September 2022, the European Parliament approved an increase to 45% by 2030 of the share of renewables in the EU's energy mix, up from 40% in June 2022 and the previous target of 32%. The new 45% target was set by the European Commission as part of the REPowerEU plan to cut the EU's dependence on imported Russian natural gas.

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 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, which forced Europe to slash its dependence on Russian oil and gas. The EU imports 90% of the natural gas it uses. Prior to the war, Russia provided about 45% of those European gas imports, according to data from the European Commission. The Commission notes that Europe also depended 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 drove natural gas prices sharply higher, which made solar even more price-competitive compared with gas. That provided another reminder that solar is not only a good environmental solution but also an economic one. 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."

SOLAR PV GROWTH OUTLOOK (CONTINUED)

The EU's climate policy chief, Frans Timmermans, added, "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."

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 often come from hostile and inhospitable places, making them an expensive, unreliable, and risky source of energy for importers.

As a result of Russia's attack on Ukraine, the EU formulated a new plan called REPowerEU to sharply reduce its dependence on Russian fossil fuels. A key strategy of REPowerEU is to rapidly build more renewable electricity to replace natural gas and coal. The RePowerEU proposal seeks to ensure that 420 GW of new solar is installed in the EU by 2030, bringing installed capacity to nearly 600 GW, roughly tripling from the current level.

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

While solar is already growing rapidly in Europe and has strong policy support, the passage of the IRA law in the U.S. caused near panic among European policymakers that the new U.S. manufacturing incentives will make it even more difficult for Europe to expand its solar manufacturing base.

U.S. passage of the IRA galvanized European policymakers into taking more aggressive action to build a domestic solar manufacturing base. The European Commission formulated the "Green Deal Industrial Plan," which is focused on the four pillars of the regulation, financing, skills, and trade.

As part of the Green Deal Industrial Plan, the EU also introduced the "Net-Zero Industry Act," which is focused on setting clean energy manufacturing goals and simplifying permitting. The EU also introduced the "Critical Raw Materials Act," which seeks to expand European access to materials that are critical for the clean energy industry.

The EU is now allowing member nations to provide whatever incentives are necessary in order to match incentives from other nations if necessary to keep a clean energy manufacturing plant in Europe. However, Europe did not devote any new money to create manufacturing incentives on the scale of the U.S. IRA law. European policymakers in coming months will be coming out with more measures to promote solar manufacturing in Europe so that

it can compete better with China, Southeast Asia, the U.S., and India.

India's solar demand expected to remain very strong

India's government is pushing solar very hard to help modernize its infrastructure, boost its global business competitiveness, expand electricity access in rural areas, and meet its climate goals. India is pursuing national goals of 450 GW of renewable capacity by 2030 and net zero emissions by 2070.

India's government set an aggressive goal of installing 293 GW of cumulative solar capacity by 2030, which is more than three times the current installed capacity of 78 GW seen at the end of 2022.

In 2022, India installed the third most solar of any country in the world, behind China and the U.S. In 2022, India installed a record 18.3 GW of solar, up +48% yr/yr, according to BNEF. BNEF forecasts that India's solar growth rate will remain strong at a compounded annual rate of +9% over the next five years, and grow 2-1/2 times to an annual install rate of 47 GW by 2030.

Solar is already big business in India, accounting for 62% of new annual electricity capacity additions and 12.4% of India's total installed electricity capacity at the end of 2021, according to PV Tech. Solar accounts for 47% of total renewable power generation in India, near wind's 48% and well ahead of biopower's 10% and small hydro's 5%, according to PV Tech.

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

India is using steep tariffs on Chinese solar panels as well as subsidies for domestic manufacturing facilities 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 much less than India's annual solar install level. India's solar manufacturers are woefully short of meeting India's outsized demand. Other problems are that India-made solar panels tend to be expensive and often do not utilize the latest solar technologies.

Although it may take time, the Indian government's new and more aggressive industrial policy plan may have some success in meeting its goal of building 90 GW of India-based solar production, enough to meet domestic needs as well as serve export markets. In the meantime, however, the Indian government's tariff policies are restricting the supply of reasonably priced panels for India's solar developers.

On the tariff side, India's government, as of April 1, 2022, imposed a basic customs duty of 40% on imported solar modules and a

SOLAR PV GROWTH OUTLOOK (CONTINUED)

25% duty on imported solar cells.

In addition, India maintains an "Approved List of Models and Manufacturers" (ALMM) of solar panels that are approved for installation in India. That list was originally designed as a minimum quality requirement, but it is actually a domestic content requirement since there are no non-India solar manufacturers on the list. The Indian government in early 2023 announced a 1-year suspension of the ALMM to allow the use of foreign panels since there simply aren't enough panels produced in India to meet demand.

On the production side, India's government has a hefty \$3 billion of funding for its solar PV manufacturing "Production Linked Incentive" (PLI) scheme. The program provides subsidies to companies that build large PV manufacturing plants in India. The government has already granted \$600 million of that funding to three companies. The government is in the process of deciding which companies will receive additional funding to help cover the costs of building India-based solar manufacturing plants.

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

Solar installs in Japan in 2022 fell by -3% yr/yr to 6.2 GW, according to BNEF. Japan's solar installs in 2023 will fall by another -9% to 5.7 GW, stabilize in the mid-5 GW area during 2024-26, and then resume solid growth during 2027-2030, 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.

Meanwhile, the Japanese government, in April 2022, launched a new feed-in-premium (FIP) support program for large-scale projects. The new FIP program gives 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 new system's goal is to transition the Japanese solar market to unsubsidized parity.

The Japanese government is pursuing aggressive solar targets and is relying on solar to help meet its emissions goals. In July 2021, the Japanese government almost doubled its solar target to a cumulative capacity of 108 GW by 2030. The government raised its solar target to help meet Japan's carbon target of cutting greenhouse gas emissions by 43% by 2030 from 2013 levels and achieving net zero carbon emissions by 2050.

Solar in Japan should also see support in the coming years from Japanese corporations that want to sign solar power purchase agreements to meet their corporate renewable energy goals.

Corporate demand is expected to be a key factor driving 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 2022 rose by +34% to 2.5 GW and showed a very strong compounded annual growth rate of +37% in the 5-year period through 2022, according to BNEF. Taiwan's solar installs will show strong growth in 2023 of +23% to 3.1 GW, according to BNEF.

There is strong solar 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 to meet the government's goal of net zero emissions by 2050.

Taiwan's government is targeting a 25% renewable energy supply by 2025. The government has announced an aggressive cumulative solar 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 19% in the 5-year period through 2022. In 2020, South Korea's solar installs surged by +51% to a record 5.6 GW, although installs then fell back by -30% yr/yr in 2021 and -17% yr/yr in 2022 to 3.2 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 is considering a proposal to require that 21.5% of electricity generation capacity is derived from renewable sources by 2030. The South Korean government, in 2021, raised its nationally determined contribution under the Paris Climate Agreement to a 40% cut in emissions by 2030 from 2018 levels.

In Australia, solar installs have shown a strong compounded annual growth rate of +25% in the 5-year period through 2022. Australian solar installs surged by +38% yr/yr in 2021 but then fell back by -28% yr/yr in 2022 to 3.9 GW, according to BNEF. Australian solar will show +18% yr/yr growth in 2023, according to forecasts by BNEF.

Australia's government pledged to reduce emissions by 43% by 2030 from the 2005 level and reach net zero emissions by 2050. However, Australia needs to install 1.9 terawatts of solar to meet its net-zero target by 2050, according to a report entitled "Net Zero Australia" issued by researchers at the universities of Melbourne, Queensland, and Princeton. The government is also targeting 82% renewable generation by 2030, up from the current level of 27%.

SOLAR PV GROWTH OUTLOOK (CONTINUED)

Latin America comes on strong with Brazilian dominance

Latin America is becoming a major player in the solar industry due to rapid solar growth in Brazil, Mexico, and Chile.

Annual solar installs in the fifteen largest Latin American countries soared by +52% in 2022 to 18.4 GW, which isn't far behind the U.S. install level of 24 GW, according to BNEF. Solar growth in Latin America has shown a compounded annual growth rate over the last five years of +44%.

Solar growth in Latin America is heavily concentrated in Brazil, which accounted for 77% of total solar installs in Latin America in 2022. Brazil's annual solar installs soared by +83% in 2022 and have shown a compounded annual growth rate over the last five years of +60%.

Chile was the second largest Latin American solar player in 2022 with 1.9 GW of solar installs, accounting for 10.5% of total Latin American installs. Mexico was the third largest solar player in 2022 with 1.6 GW of installs, accounting for 8.9% of total Latin American installs.

SOLAR PV ANNUAL NEW INSTALLATIONS

New global solar PV installations in 2022 rose by +39% to a new record high of 252 gigawatts (GW), according to Bloomberg New Energy Finance (BNEF). That added to the strong growth rates of +24% in 2020 and +25% in 2021. Global solar installations have grown by a compounded annual rate of +20% over the last five years and have risen 14-fold since 2010.

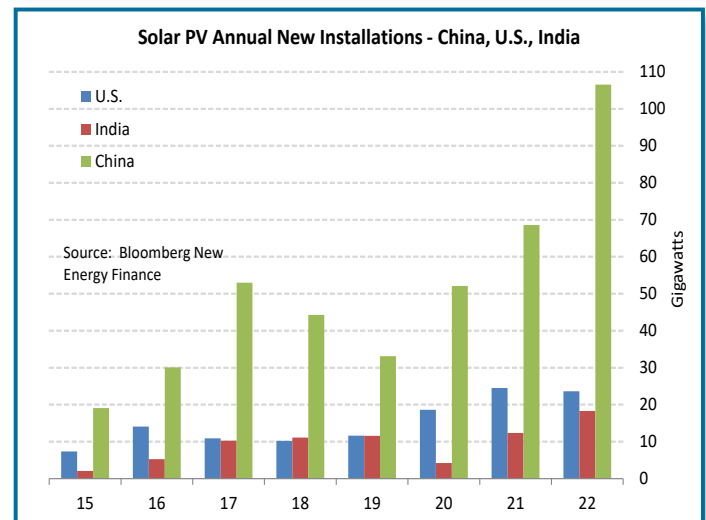
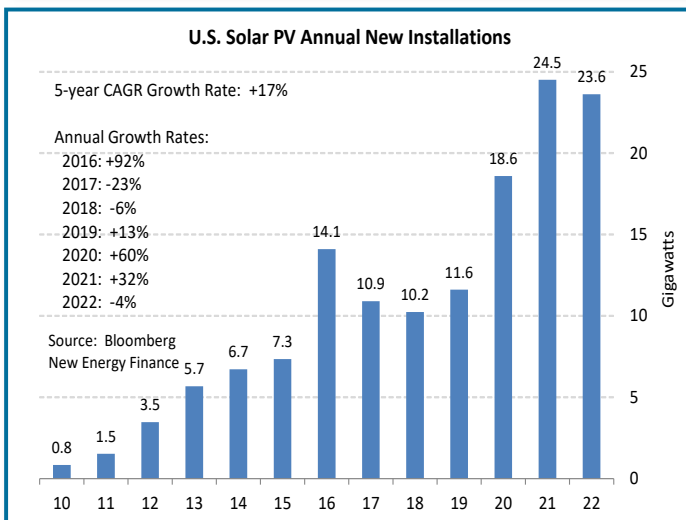
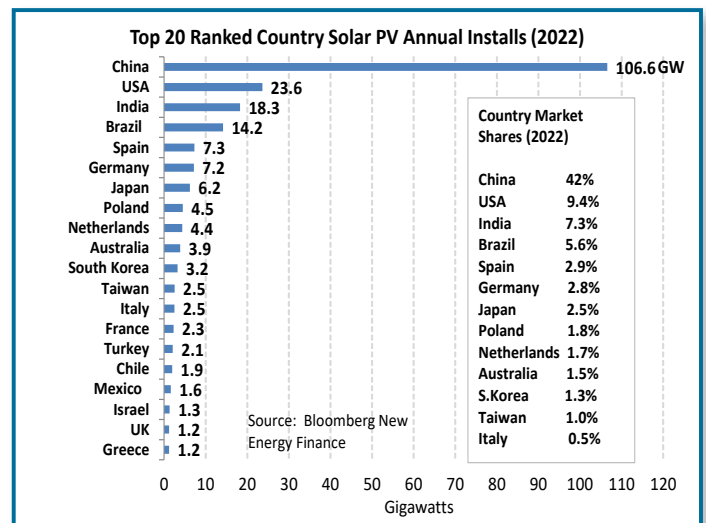
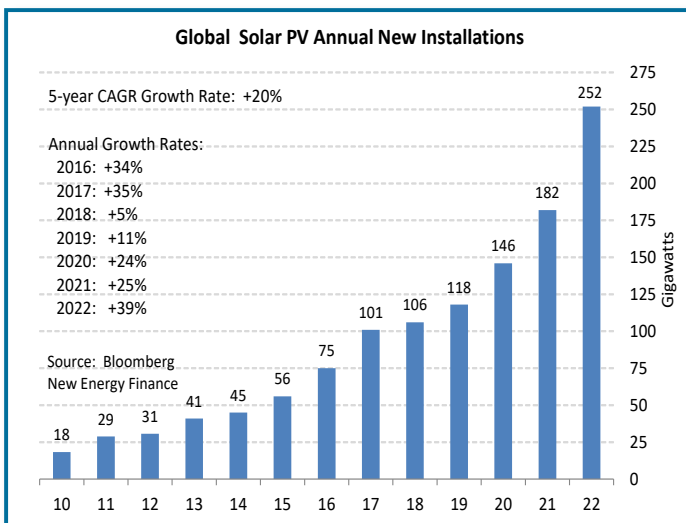
In 2022, China led the world in annual new solar installs for the tenth straight year with a record 107 GW of installs, up +55% yr/yr, according to BNEF. The U.S. maintained its second-place position with 23.6 GW of installs, but that was down by -4% yr/yr due to tariffs and import restrictions. India remained in third place with 18.3 GW of installs, up sharply by +48% yr/yr. Brazil jumped into fourth place with 14.2 GW of installs, up +83% yr/yr. Spain was in fifth place with 7.3 GW of installs, up +60% yr/yr. Germany was in sixth place with 7.2 GW of installs, up +21% yr/yr.

There were 21 countries in 2022 with installs above 1 GW, more than twice as many countries seen as recently as 2017.

That illustrates the spread of solar across the world and the diversification of the industry. Fitch forecasts that 36 nations will install more than 1 GW of solar by 2029.

Solar growth in Europe in 2022 grew sharply by +32% yr/yr, adding to the +38% growth rate seen in 2021. The largest PV install amounts were Spain with 7.3 GW (+60%), Germany with 7.2 GW (+21% yr/yr), Netherlands with 4.3 GW (+14%), and Italy with 2.5 GW (+165%), according to BNEF.

U.S. solar PV installations in 2022 fell by -4% yr/yr but grew at a compounded annual rate of +17% over five years through 2022 and rose 28-fold from 2010, according to BNEF. The states with the largest amount of new PV solar installations in 2022 were California with 4.7 GW (+31% yr/yr), Texas with 3.4 GW (-44% yr/yr), and Florida with 1.9 GW (+14% yr/yr), according to SEIA/Wood Mackenzie.



SOLAR PV CUMULATIVE INSTALLATIONS

The amount of cumulative PV electricity generation capacity across the world in 2022 grew sharply by +26% yr/yr to 1.2 terawatts (TW), according to Bloomberg New Energy Finance (BNEF). In the last five years, global cumulative solar PV electricity generation capacity has increased by nearly 3-fold and has risen by a compounded annual growth rate of +24%.

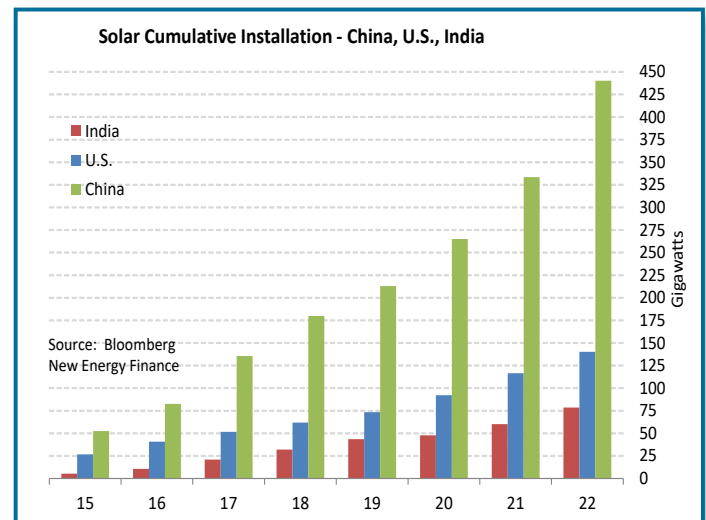
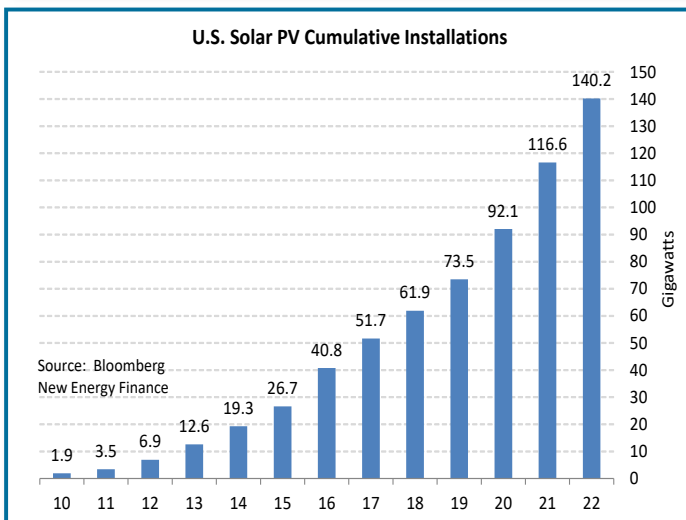
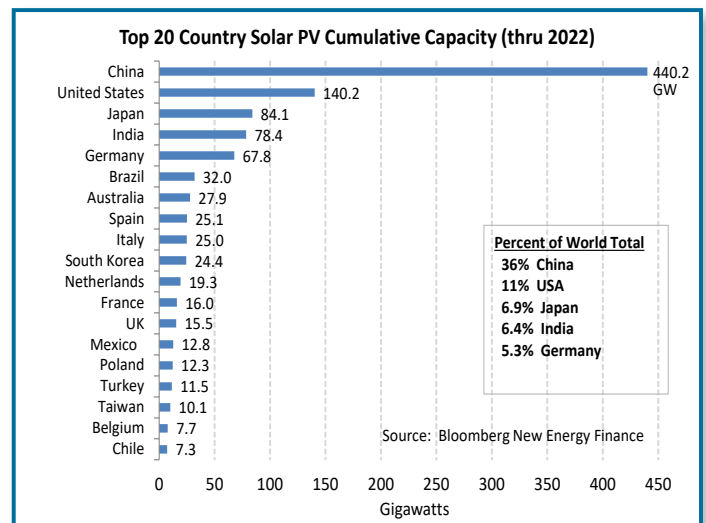
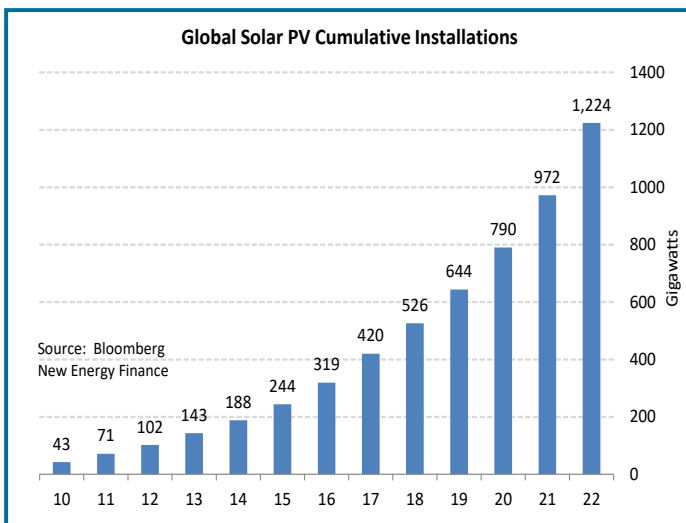
China, in 2022, continued to be the world's leader for cumulative solar capacity at 440 GW, up +32% yr/yr, according to BNEF. At the end of 2022, China accounted for 36% of the world's solar PV capacity. In the past five years, China's cumulative installed solar capacity soared by more than 3-fold and showed a 5-year compounded annual growth rate of +27%.

The U.S., in 2022, remained in second place for cumulative solar installs. U.S. solar electricity capacity in 2022 rose by +20% yr/yr to 140 GW, representing 11% of world capacity. Over the past

five years, U.S. cumulative solar electricity capacity rose by nearly 3-fold and showed a compounded annual growth rate of +22%.

Japan remained in third place for the ninth straight year. Japan's cumulative solar capacity in 2022 rose by +8% to 84 GW, representing 6.9% of world capacity. Japan's cumulative solar capacity in the past five years has risen 1.7-fold and showed a 5-year compounded annual growth rate of +11%.

India, in 2022, remained in fourth place with 78 GW of cumulative solar PV capacity, up +30% yr/yr. In the past five years, India's cumulative solar capacity has risen nearly 4-fold and has shown compounded annual growth of +33%. India accounted for 6.4% of the world's total solar PV capacity as of the end of 2022.



LEVELIZED COST OF SOLAR ELECTRICITY

Solar electricity's cost remains cheaper than fossil fuels

The lower end of the range of the levelized cost of electricity (LCOE) for newly-built U.S. utility-scale crystalline solar PV plants as of early 2023 fell by -8% to \$24 per MWh from \$26 in 2021. Lazard reported that the upper end of the range of utility solar LCOE in early 2023 rose sharply to \$96 from \$41 in 2021, which resulted in the median rising to \$60 in early 2023 from \$36 in 2021. Wind has a similar LCOE profile to that of solar.

Those figures are reported by Lazard in the latest annual edition of its comprehensive "Levelized Cost of Energy Analysis-Version 16.0" released in April 2023. Lazard did not release a report in 2022.

Those figures are calculated with the assumption of no subsidies. In real life, however, there are substantial subsidies that make solar even cheaper than the figures mentioned above. U.S. utilities have substantial subsidies at their disposal to further reduce the price of new solar plants.

Both the minimum and median LCOE for utility solar of \$24 and \$60 per MWh, respectively, remained below the median LCOE costs of \$70 per MWh for natural gas, \$117 for coal, and \$167 for nuclear. That illustrates the easy economic decision for utilities to choose solar or wind for new electricity plants, since those plants are now cheaper than fossil fuels and nuclear.

Moreover, the \$24 per MWh lower end of the LCOE range for building a new utility solar plant is below the marginal costs for operating an existing plant of \$31 for a nuclear plant, \$52 for a coal plant, and \$62 for a natural gas plant.

That means that if a utility can construct a solar plant near the lower end of Lazard's reported LCOE range, there is an incentive for the utility to mothball existing nuclear, coal, and natural gas plants and replace them with a new solar or wind plant.

Solar has big potential as a replacement technology since many coal and nuclear plants are reaching the end of their useful lives. The average U.S. coal plant is 45 years old, and the average U.S. nuclear plant is 40 years old, according to the U.S. Energy Information Administration. As coal and nuclear plants are retired, many utilities will decide to switch to building new solar and wind plants based simply on economics.

The low cost of solar is a global phenomenon. Utility-scale solar and wind "are now the cheapest sources of new electricity generation in countries accounting for 82% of the world's power supply and 85% of global GDP," according to BNEF ("Renewables Now Undercut Fossil Fuels in Most Countries, Bloomberg New Energy Finance, 6/8/2023).

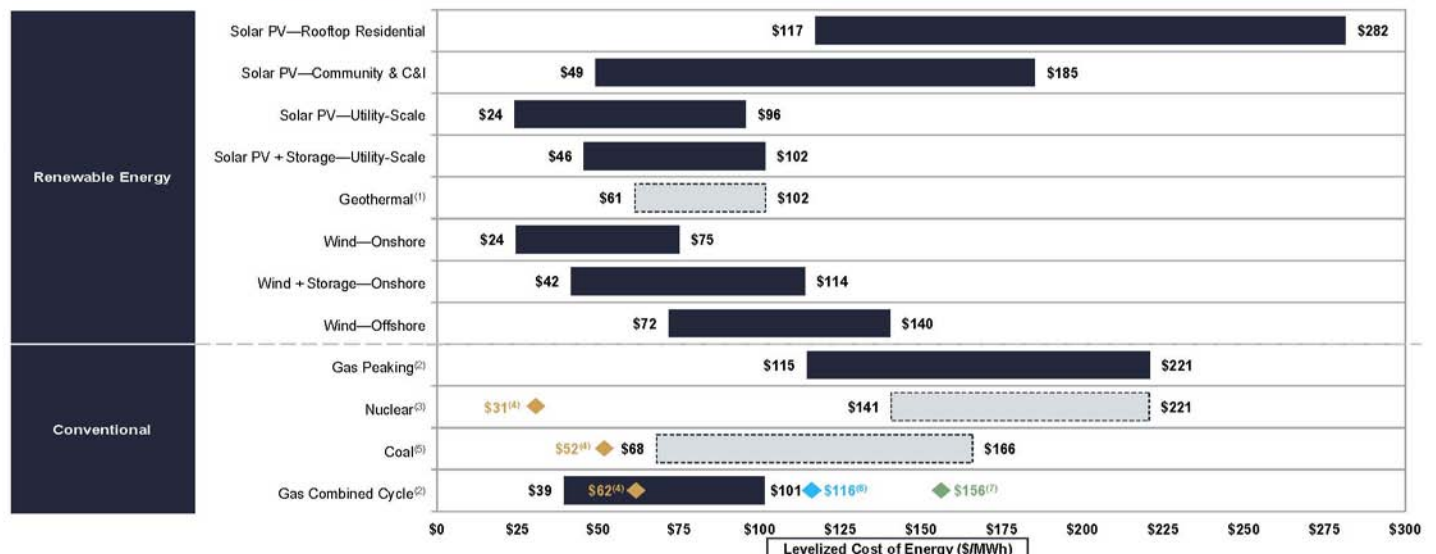
BNEF reports that renewables are now the cheapest form of electricity generation in 16 of the G-20 countries, i.e., all except for Indonesia, Russia, Saudi Arabia, and South Korea.



LAZARD'S LEVELIZED COST OF ENERGY ANALYSIS—VERSION 16.0

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 - April 2023, Version 16.0.

PRICING - SOLAR MODULES, CELLS, AND POLYSILICON

Solar module prices have edged to record lows. The price of standard monocrystalline silicon modules fell to a new record low of 15.5 USD cents per watt in September 2023, according to PV Infolink. Monocrystalline silicon modules have fallen by -40.6% yr/yr, and by an overall -90% since 2010.

Meanwhile, the price of thin-film modules edged to a record low of 20.4 cents per watt in September 2023, according to PV Insights. Thin-film module prices have fallen by -13.6% yr/yr and by an overall -84% since 2010.

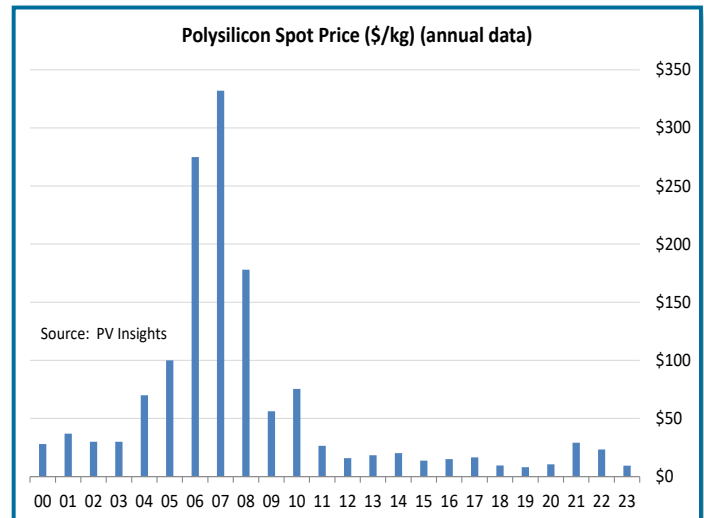
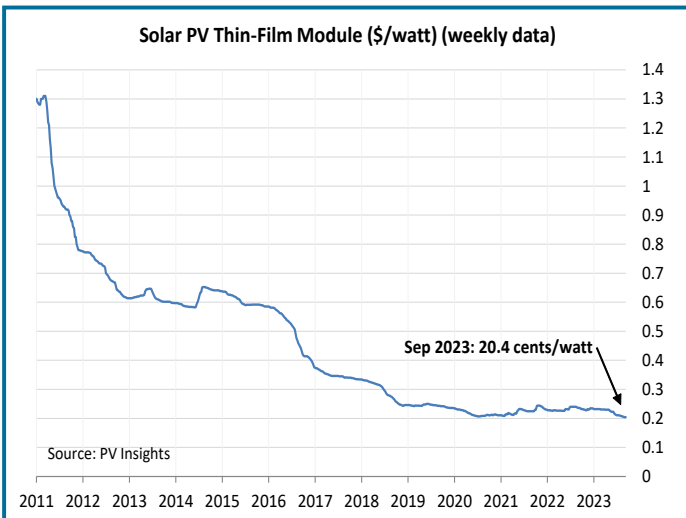
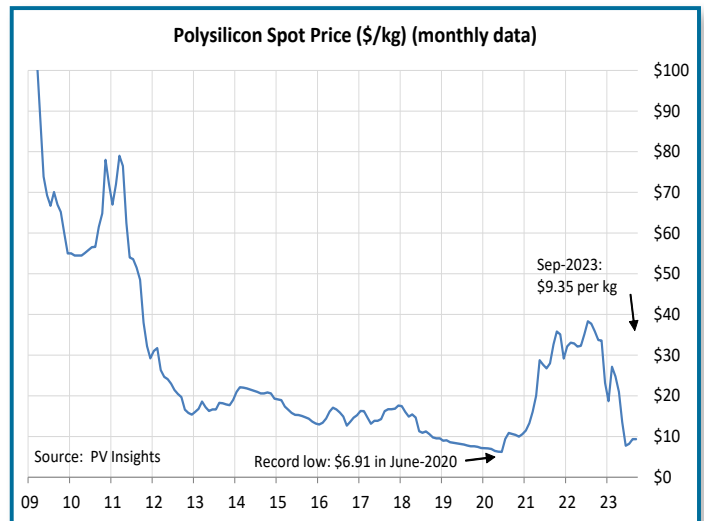
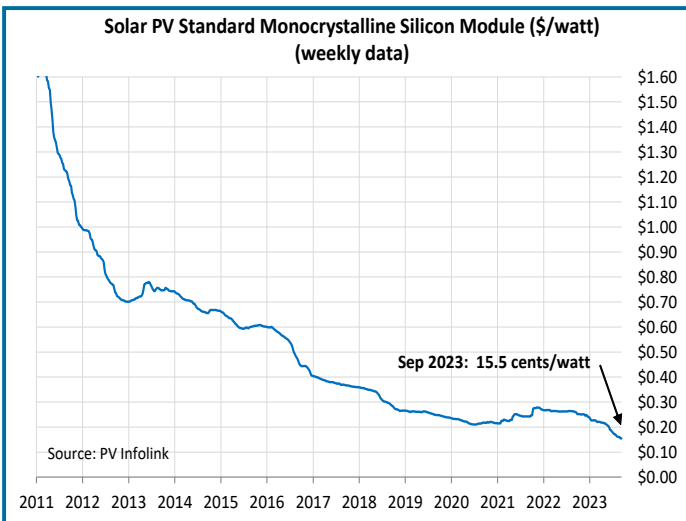
Solar module prices temporarily rose in 2020-22 due to strong demand, high polysilicon input prices, pandemic disruptions, higher costs for other materials, and high shipping costs.

However, the long-term decline in module prices has now resumed due to new production capacity coming online and long-term secular factors such as technological advancements and manufacturing economies of scale. The decline in module prices

should stimulate fresh demand and higher unit sales as solar becomes even cheaper relative to its competitors.

Spot polysilicon prices have plunged in the past year and posted a 3-year low of \$7.72 per kg in June before recovering to \$9.35 in September, according to PV Insights. Polysilicon prices have so far remained above the record low of \$6.90 per kg posted in May 2020 during the early stage of the pandemic.

Polysilicon prices rose sharply in 2021-22 due to strong demand and various supply disruptions such as fires, flooding, regional power rationing, and the avoidance of polysilicon from the Xinjiang province. However, polysilicon prices have fallen sharply since late 2022 because a large amount of new polysilicon production capacity has come online, and various supply disruptions have abated. The decline in the price of polysilicon, the key ingredient in silicon solar cells and modules, has made room for a drop in module prices.



SOLAR JOBS

U.S. solar jobs, as of December 2022, rose by +3.5% to a record high of 263,883 jobs from 255,037 jobs in 2021, according to the "National Solar Jobs Census" published by the Interstate Renewable Energy Council (IREC). The report is available at www.SolarJobsCensus.org.

The report is based on a survey conducted by the U.S. Department of Energy for the *United States Energy & Employment Report (USEER) 2023* and was administered by BW Research Partnership.

The U.S. solar industry during the 10-year period of 2012-2022 added 144,866 jobs to the U.S. economy, rising by a total of +122% over that period and showing compounded annual growth of +8%.

Solar jobs rose in 2022 as the pandemic faded and solar installs boomed. Residential jobs grew by about 9,500 jobs (+11%), outweighing a loss of about 6,000 jobs in the utility sector caused by a shortage of solar modules.

U.S. solar jobs will likely increase sharply beginning in 2023-24 as new U.S. solar manufacturing facilities are built in response to the U.S. Inflation Reduction Act. Over the next ten years, the Solar Energy Industry Association is expecting U.S. solar jobs to nearly double to 475,000, with 100,000 of those jobs in manufacturing.

Regarding the sector breakdown, the survey found that 65% of U.S. solar jobs are at installation and project management firms, 13% at manufacturing firms, 12% in wholesale trade and distribution, 6% in operations and maintenance (O&M), and 4% in a miscellaneous "all others" category.

The number of solar jobs in the U.S. exceeds those in the fossil fuel industries. Specifically, the 263,883 jobs in the solar sector far exceed the 117,200 direct jobs in the oil/gas extraction industry and 41,100 direct jobs in the coal mining industry at the end of 2022, according to figures from the U.S. Bureau of Labor Statistics (see chart on the right).

Globally, solar PV is a huge employer, with 4.3 million solar jobs worldwide at the end of 2021, up by +8% from 4.0 million at the end of 2020, according to the "Renewable Energy and Jobs -- Annual Review 2022" from the International Renewable Energy Agency (IRENA).

China is far ahead of the U.S. in solar PV jobs, with a total of 2.7 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 significant solar PV employment include Europe with 268,000 jobs, India with 137,000 jobs, and Japan with 151,000 jobs, according to IRENA.

