

## 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 INDEX PERFORMANCE

The MAC Global Solar Energy Stock Index rallied over the summer and is up +11% on a year-to-date basis. The MAC Solar Index in 2021 fell by -26% after two years of extraordinary gains of +67% in 2019 and +245% in 2020.

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 are seeing support from very strong global demand for solar installations driven by solar's low cost and the need to reduce carbon emissions. In addition, the sector received a big boost in August when Washington approved a \$369 billion climate law, representing the single largest U.S. climate investment in history. The new law contained a 10-year extension of the solar investment tax credit (ITC) and also a solar production tax credit to encourage building solar manufacturing plants in the U.S.

Solar stocks have been able to shake off negative factors such as rising interest rates, high polysilicon prices, the U.S. Department

of Commerce's tariff investigation, and disruptions to U.S. panel imports due to the new Xinjiang law.

Despite the recent obstacles, bullish longer-term factors for solar stocks 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 risk of importing fossil fuels from hostile areas.

### Solar stocks out-perform on bullish long-term solar industry trends

The MAC Solar Index in 2022 has risen +11% year-to-date and has fared much better than the broad stock market, where the Nasdaq 100 index has fallen by -27% year-to-date.

The MAC Solar Index has more than doubled from its pre-pandemic level on the strong long-term prospects for the solar industry. 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 exceeded the supply of available panels, which means the solar growth rate would be even higher if enough panels were available.

The global solar industry in recent years has proven its resilience by responding to rising demand and shifting government policies. The solar industry also shook off the pandemic, showing strong growth rates of +23% in 2020 and +26% in 2021, according to data from Bloomberg New Energy Finance. The long-term growth theme for the solar industry remains intact, with BNEF forecasting +32% yr/yr solar growth in 2022 and more than \$4 trillion of spending on solar equipment 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 +38% yr/yr to a record high of 251 GW, which would be the fourth consecutive year of double-digit growth.

In 2021, global solar growth rose by +26% to 182 GW, adding to the growth rates of +11% in 2019 and +23% in 2020, according to BNEF. New global solar installs grew by a compounded annual growth rate of +19% over the 5-year period of 2017-2021.

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 solar industry, over the past two years, has shown very strong growth. The solar industry has been able to shake off obstacles such as the pandemic shutdowns, high commodity prices, supply chain constraints, high 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 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 should surge in the coming years as solar costs decline and as solar becomes even more competitive against fossil fuels and nuclear. Solar's levelized cost has already plunged by an overall -85% since 2010 and by an average -8% per year over the five years through 2021, according to Lazard (see p. 12).

### 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 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 has now 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 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 +44% to 98.8 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 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 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

## SOLAR PV GROWTH OUTLOOK (CONTINUED)

generous subsidies exist. 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 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 (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 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.

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 that the companies were involved with government-run forced labor programs of the Uyghur Muslim minority. China's government strenuously denied the forced-labor allegations and objected to what it believes is U.S. interference in its internal affairs.

At least one of the targeted companies strenuously denied the use of forced labor. 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.

However, Chinese companies are largely prevented from defending themselves against allegations of forced labor because of China's Anti-Foreign Sanctions Law, which makes it illegal for Chinese companies to comply with U.S. requirements to avoid sanctions. Some Chinese companies are therefore caught in a Catch-22 situation sparked by the difficult political climate between the U.S. and China.

The U.S. Congress in December then passed the Uyghur Forced Labor Prevention Act (UFLPA), which was signed into law by President Biden and took effect on June 21, 2022. This 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.

It is important to note that the UFLPA does not impose a total ban against importing goods from Xinjiang, only a rebuttable presumption of a ban that can be overcome with proper

documentation.

The global solar industry is adjusting to the Xinjiang labor issues by building new polysilicon plants outside Xinjiang and creating better supply chain documentation. Factories in the Xinjiang region produced about 45% of the world's solar-grade polysilicon in 2020, according to Bernreuter Research. Still, there is plenty of polysilicon available to build solar panels for the U.S., Europe, and other countries that may blacklist Xinjiang.

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. and global solar companies have been aware of the Xinjiang risk for the last two years. They 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 Solar Energy Industries Association (SEIA) is confident that the U.S. solar industry will be able to adjust to the Xinjiang requirements. "We believe that the information that Customs is seeking can be obtained and it is our expectation that most companies should be able to meet the requirements of the UFLPA," said SEIA vice president of public affairs, Dan Whitten.

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 is constrained by panel supply

U.S. solar growth in 2021 saw continued strength, with +32% yr/yr growth to a new record of 24.5 GW, adding to the +60% 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 PV GROWTH OUTLOOK (CONTINUED)

Solar accounted for an impressive 46% of all 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. However, solar accounted for only 3.9% of total U.S. electricity generation in 2021, showing there is plenty of headroom for massive solar growth in the coming decades.

Solar remained first among all the U.S. electricity generation technologies for the third straight year with its 46% share in 2021, beating the 44% share for wind and 10% share for natural gas. The share of new natural gas electricity additions fell further to 10% in 2021 from 18% in 2020 and 57% as recently as 2018. Solar and wind together accounted for a combined 90% of new electricity capacity installs and dramatically shoved aside natural gas. Neither coal nor nuclear registered any measurable new installs in 2021, according to Wood Mackenzie.

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 demand continues to be very strong in 2022 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, this strong demand is not being met because of various actions by the U.S. government that have restricted the supply of solar panels available to U.S. developers.

Largely due to the tariff investigation by the U.S. Department of Commerce (DOC), U.S. solar growth stalled in the first half of 2022. BNEF cut its U.S. solar forecast and is now projecting no U.S. solar growth in 2022, with installs of 25 GW that would be little changed from the 2021 level.

Specifically, the U.S. Department of Commerce on March 25, 2022 opened a quasi-judicial investigation into whether Chinese companies are circumventing the decade-old anti-dumping and countervailing (AD/CVD) tariffs with their factories in Malaysia, Thailand, Vietnam, and Cambodia. Those countries currently account for about 80% of the \$7 billion worth of solar cell and module 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 stands to benefit from reduced competition if the Department of Commerce extends the tariffs to Southeast Asia.

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.

The Department of Commerce originally had a deadline of August 2022 to announce a preliminary determination on the investigation. However, the DOC announced in August that it would delay the deadline for its preliminary determination until November 28, 2022. The Department of Commerce is also likely to push back the deadline for a final determination from the current deadline of January 27, 2023.

The DOC investigation threw the U.S. solar industry into turmoil with its antiquated investigation procedures that are based on a 92-year-old trade law.

President Biden, on June 6, 2022, provided some relief from the tariff investigation by announcing that his administration would provide 2-year waiver relief from any tariffs that might be imposed as a result of the DOC investigation. That move gave the solar industry a 2-year window to buy panels without fear of new tariffs, assuming the Biden waiver can withstand any legal challenges.

From a legal standpoint, the Biden administration cannot directly interfere in the DOC's quasi-judicial tariff investigation but did find a way to nullify the investigation for at least two years with the tariff waiver announcement. Nevertheless, the DOC investigation will continue to cause uncertainty for the U.S. solar industry until it is concluded and the final results are known.

Yet, the good news for the global solar industry is that the U.S. investigation affects only U.S. solar installs, which represented only 14% 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, meaning the overall global solar install rate is likely to remain strong. Moreover, the U.S. investigation will only temporarily affect U.S. installs, which can return to strong levels in line with demand once solutions are implemented and the investigation ends.

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 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 large utility-scale projects widely use those panels. 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. 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.

## SOLAR PV GROWTH OUTLOOK (CONTINUED)

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 for another four years.

On the Washington policy front, the 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.

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 \$369 billion climate bill was less than the \$550 billion of energy and climate spending that was contained in President Biden's original \$1.7 trillion Build Back Better bill (BBB). However, the clean energy industry received much of what it wanted from Washington in the final bill. The final bill was named the "Inflation Reduction Act" since the bill was designed in part to reduce healthcare and energy costs for consumers.

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% for some projects depending on the type of organization, domestic product use, labor factors, and project location.

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.

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. At least two major global solar manufacturing companies announced that they will build new solar manufacturing plants in the U.S. as a result of the new production tax credit.

The Inflation Reduction Act also provided a big boost for residential solar by providing a 30% tax credit for residential solar systems installed from 2022 through 2034. The credit will also apply 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 at all.

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 and is self-sustaining without any subsidies. However, the new policy support from the U.S. government will give the solar industry an even bigger 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 next five years (2023-2027).

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 new U.S. climate legislation is expected to provide its biggest benefits after 2024. U.S. solar installs are currently being constrained by the Department of Commerce's tariff investigation and by the U.S. import restrictions from Xinjiang. Due to solar panel supply constraints, U.S. solar installs are expected to be weak in 2022, with residual weakness lasting into 2023. However, the industry is then expected take off in 2024, with BNEF predicting that U.S. solar installs will soar by +48% yr/yr in 2024 and show further growth of +12% in 2025. By 2030, BNEF is predicting that annual U.S. solar installs will nearly double from the 2021 level.

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

In an ambitious goal, the Biden administration wants to boost U.S. solar production to 22.5 GW by 2024, which would triple

## SOLAR PV GROWTH OUTLOOK (CONTINUED)

the current amount of U.S. solar production. The U.S. currently produces only about 7.5 GW of PV, representing only 30% of U.S. solar installs of 25 GW in 2021 and only 2% of world PV production of about 400 GW, according to Wood Mackenzie.

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 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 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" published by SolarPower Europe. That was the fourth consecutive year of very strong solar growth for Europe. Solar now produces 6% of Europe's total electricity, according to thinktank Amber.

In 2021, the largest European national solar install amounts were in Germany with 5.9 GW (+22% yr/yr), Spain 4.6 GW (+50%), Netherlands 3.8 GW (+8%), and France 2.8 GW (+187%), 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 increased solar power to meet its aggressive emission-reduction targets.

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. 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 that 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 its 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

## SOLAR PV GROWTH OUTLOOK (CONTINUED)

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, 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 but is also an economical 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."

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 plans 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 scrapped the approval process for the Nord Stream 2 gas pipeline from Russia to the EU, putting the project into an indefinite freeze and forcing the Gazprom-backed Nord Stream company towards insolvency.

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, more than tripling from the end-2021 level of about 160 GW. That would require the average annual solar installation of 47 GW of solar over the next nine years, which is more than 80% higher than the 2021 install level of 25 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 REPowerEU strategy includes several key measures for accelerating 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 to help modernize its infrastructure, boost its global business competitiveness, expand electricity access in rural areas, and meet its climate goals. At the COP26 conference in late 2021, India 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 forecasts 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 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 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 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

## SOLAR PV GROWTH OUTLOOK (CONTINUED)

manufacturing capacity of 8.8 GW for solar modules and 2.5 GW for solar cells is much less than India's 2021 annual solar install level of 12.4 GW, according to PV Tech. 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.

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 exceeds supply. In fact, some solar developers are currently curbing their solar building plans in India because of the high price and the limited number of solar panels that are currently available domestically in India.

Although it may take time, the Indian government's new and more aggressive industrial policy plan may have some success in reducing its reliance on 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.

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. In addition, India maintains an "Approved List of Models and Manufacturers" (ALMN) of solar panels that are approved for installation in India. That list 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 while much of the rest of Asia/Pacific is soaring

Solar installs in Japan in 2021 fell by -26% to 6.4 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 -21% 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 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 goal of the new system is to transition the Japanese solar market to unsubsidized parity.

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 43% by 2030 from 2013 levels and achieving net zero carbon emissions by 2050.

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 rose by +9% to 1.8 GW, slowing after extraordinary growth rates of +109% in 2017, +91% in 2018, +41% in 2019, and +18% in 2020, according to BNEF. Taiwan's solar installs will show strong growth in 2022 of +29% to 2.4 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 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



## SOLAR PV GROWTH OUTLOOK (CONTINUED)

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 comes 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 in 2021 grew sharply by +25% to 4.7 GW, capping a 5-year compounded annual growth rate of 39% seen during 2017-21, according to BNEF. BNEF projects that Australia's solar installs in 2022 will fall slightly to 4.6 GW.

Australia's government has adopted a pledge 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.

## SOLAR PV ANNUAL NEW INSTALLATIONS

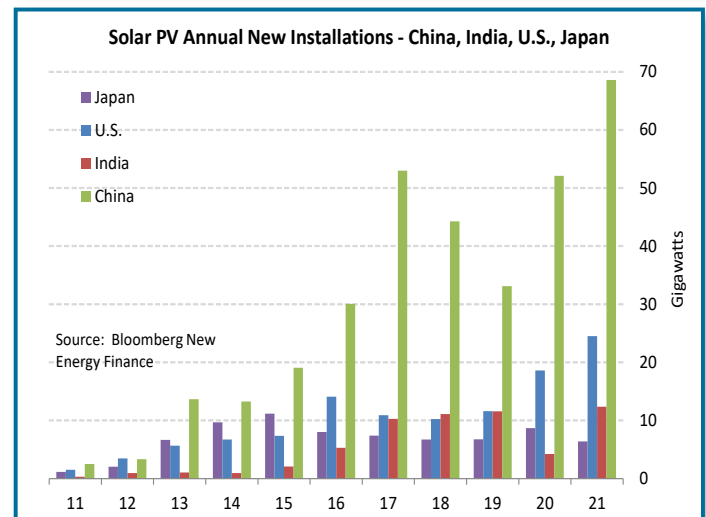
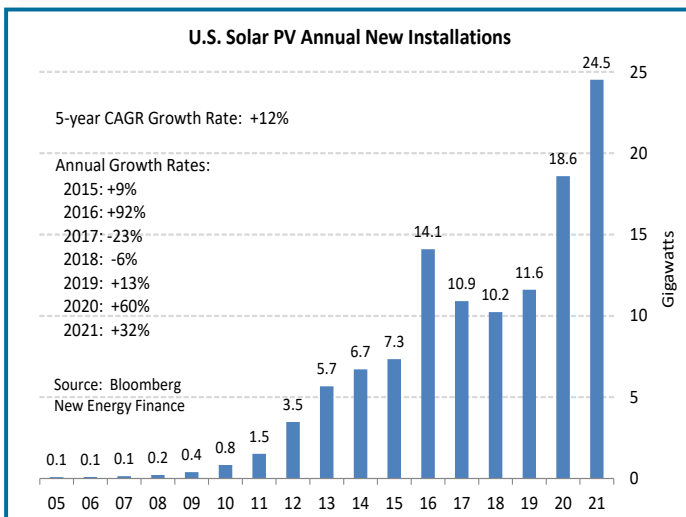
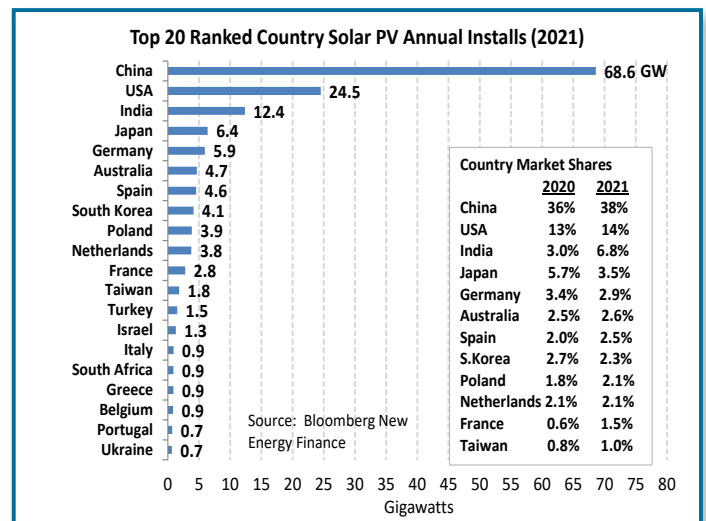
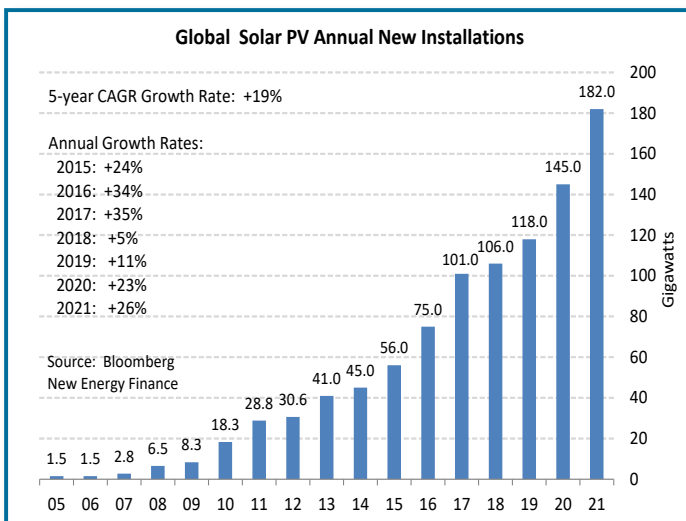
New global solar PV installations in 2021 grew by +26% yr/yr to a record 182 gigawatts (GW), according to Bloomberg New Energy Finance (BNEF). Solar growth in 2021 was even stronger than the +23% growth rate seen in 2020. Solar growth in 2020-21 defied the pandemic lockdowns and supply disruptions and rose to new record levels. Global solar installations have grown by a compounded annual rate of +19% over the last five years and have risen 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 +32% yr/yr growth to 24.5 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 -26% decline in growth to 6.4 GW from 8.7 GW in 2020. Germany slipped into fifth place from fourth place despite +22% growth to 5.9 GW.

There were 14 countries in 2021 with installs above 1 GW, twice as many 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 +40% yr/yr. The largest PV install amounts were in Germany with 5.9 GW (+22% yr/yr), Spain 4.6 GW (+50%), Netherlands 3.8 GW (+8%), and France 2.8 GW (+187%), according to BNEF.

U.S. solar PV installations in the five years through 2021 grew at a compounded annual rate of +12% 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 (17-fold), 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%.

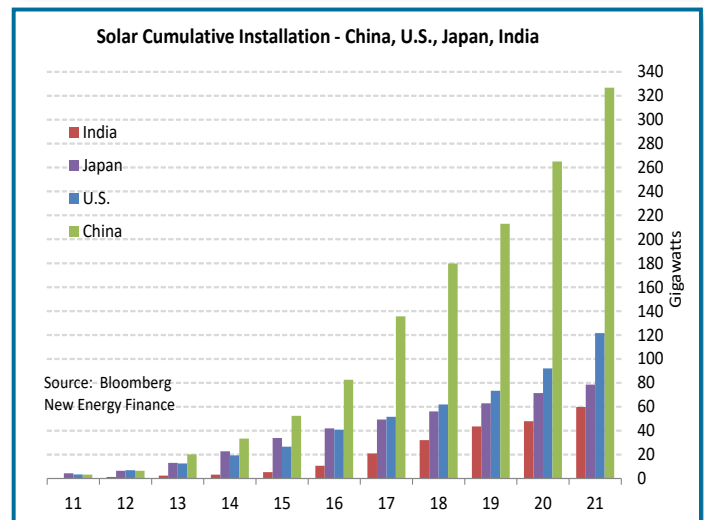
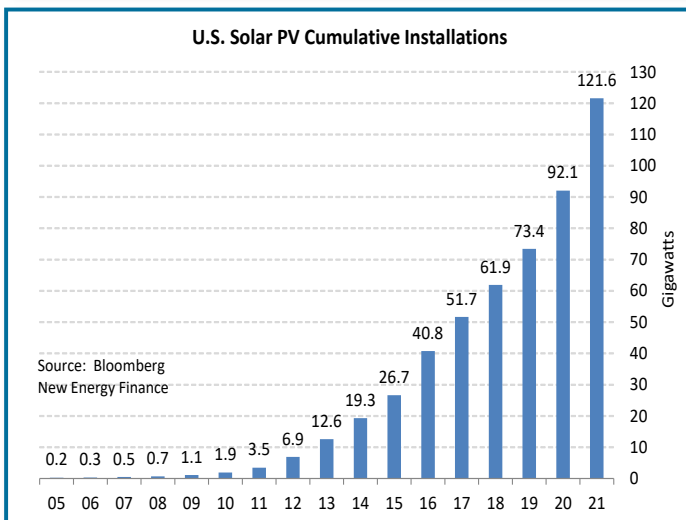
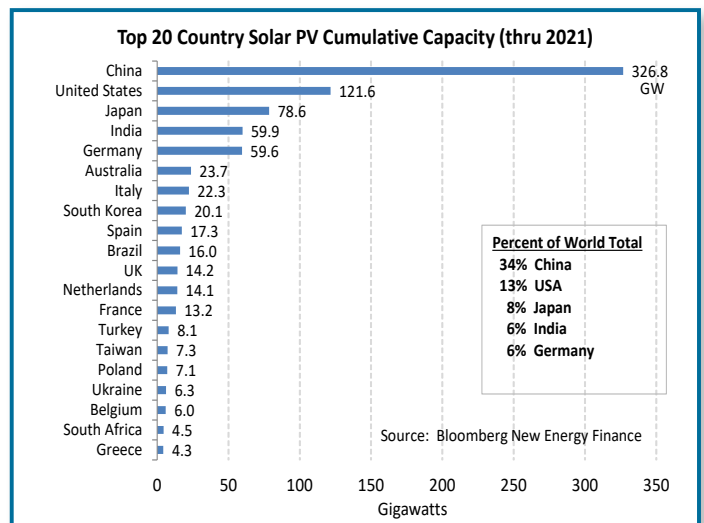
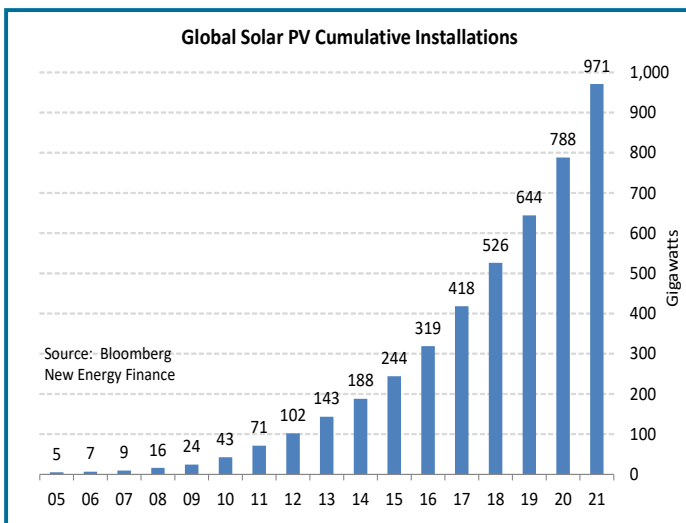
China in 2021 continued to be the world's leader for cumulative solar capacity at 327 GW, according to BNEF. China, at the end of 2021, accounted for 34% of the world's solar PV capacity. In the past five years, China's cumulative installed solar capacity soared 4-fold from 82 GW in 2016 to the 2021 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 more than 3-fold to 122 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 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 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 at \$29/MWh or a natural gas plant at \$24/MWh.

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, 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.<sup>1</sup>

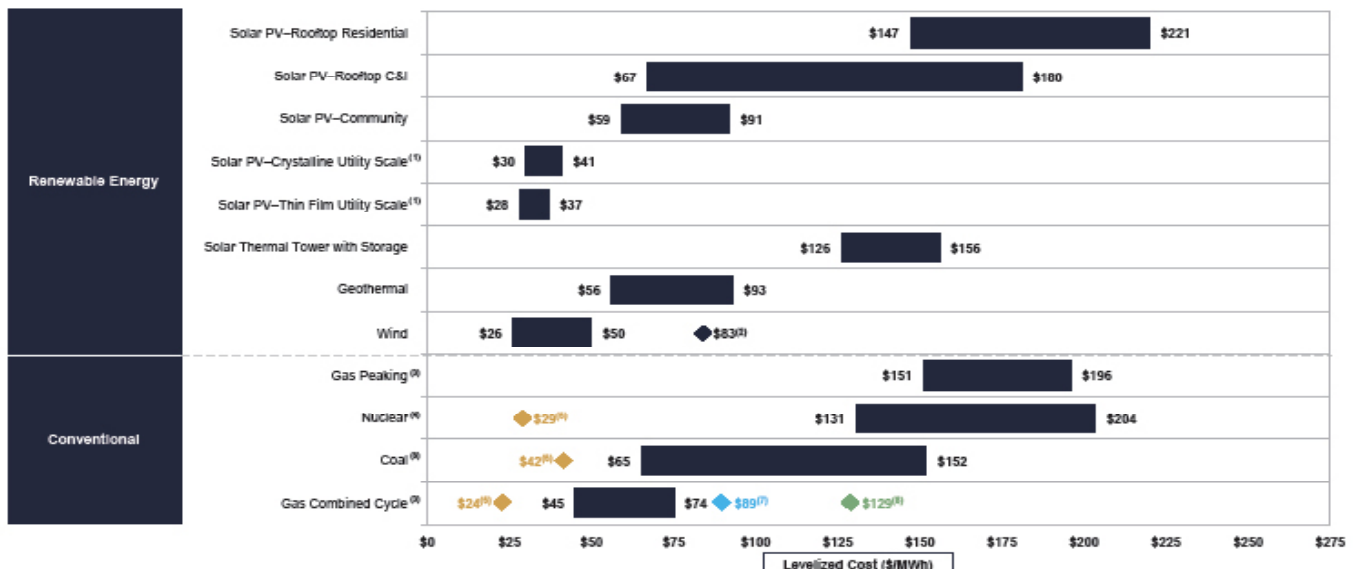
<sup>1</sup> BNEF, "The First Phase of the Transition is about Electricity, 1/28/2020.

### LAZARD

LAZARD'S LEVELIZED COST OF ENERGY ANALYSIS—VERSION 15.0

### 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 - 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 USD cents per watt in July 2020 but has since risen to the current level of 21.5 cents, according to PV Insights. Since 2010, silicon module prices have still 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 23.6 cents, according to PV Insights. Since 2010, thin-film module prices have plunged by a total of -82%.

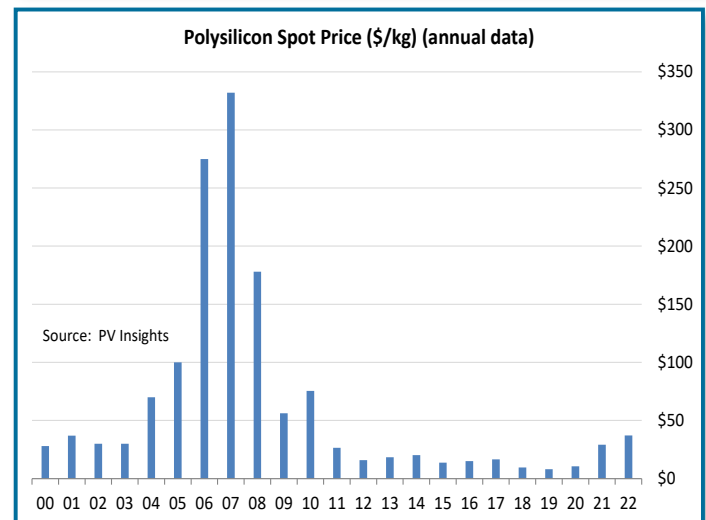
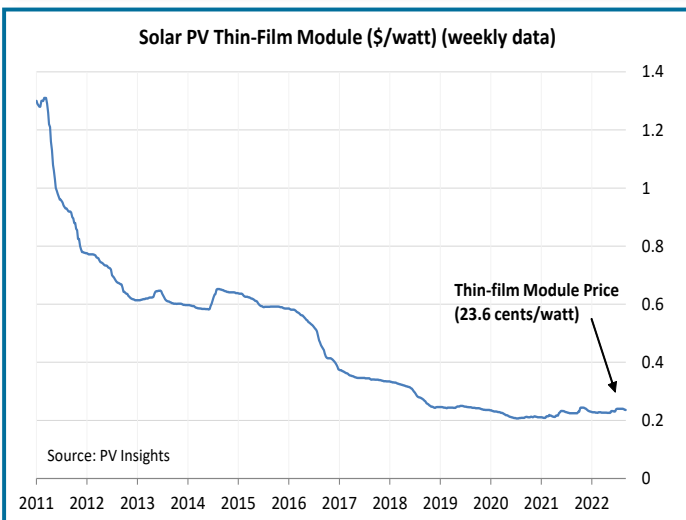
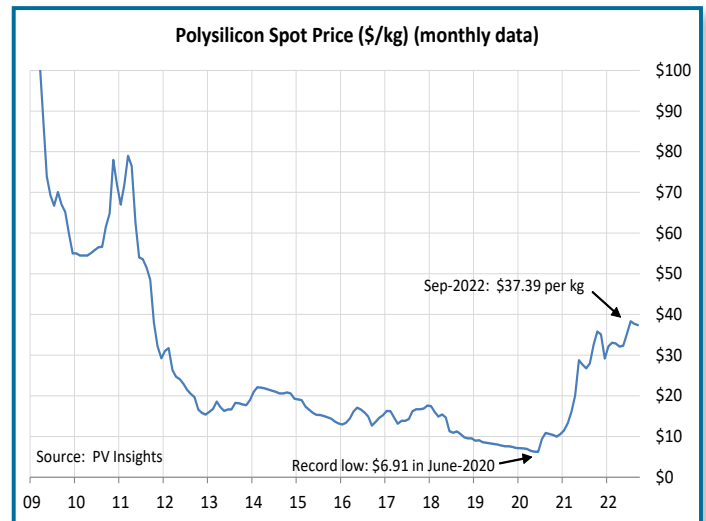
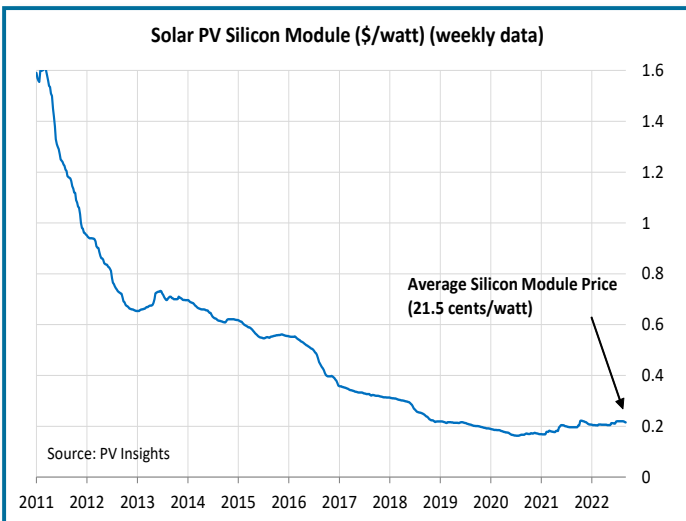
Solar module prices have risen in the past two years due to strong demand, higher polysilicon input prices, higher costs for other materials, and high shipping costs.

Spot polysilicon prices fell to a record low of \$6.90 per kg in May 2020. Polysilicon prices rose to an 11-year high of \$38.32 in August 2022 but have since slipped to \$37.39, according to PV Insights. Polysilicon prices are down by -47% since 2010.

Polysilicon prices fell to a record low during the worst of the pandemic shutdowns in spring 2020. Prices then rebounded higher due to supply disruptions such as fires, flooding, regional power rationing, and the avoidance of polysilicon from the Xinjiang province. However, the main cause of higher polysilicon prices has been strong demand, as opposed to supply restrictions, as seen by the fact that China in the first half of 2022 produced 33% more polysilicon than the year-earlier level.

Polysilicon prices should ease over the next few years due to a massive amount of new production capacity that will soon come online. BNEF notes that there is currently 2.5 million metric tons of new annual polysilicon production capacity in the pipeline, representing five times 2021 production.

Historically, solar pricing has steadily fallen due to technological advancements and manufacturing economies of scale. This trend should resume once pandemic and trade-related problems ease and new capacity comes online.



## SOLAR JOBS

U.S. solar jobs, as of December 2021, rose by +9.2% to 255,037 jobs from 233,474 jobs in 2020, according to the "National Solar Jobs Census 2021" published by The Solar Foundation in July 2022. The report is available at [www.SolarJobsCensus.org](http://www.SolarJobsCensus.org).

Solar jobs in 2021 recovered due to the strength in the U.S. solar sector and the recovery of solar jobs after the -5.9% decline seen in 2020 due to the pandemic shutdowns. The U.S. solar job level in 2021 was still below the record high of 260,077 jobs seen in 2016.

The U.S. solar industry during the 10-year period of 2011-2021 added 154,800 jobs to the U.S. economy, rising by a total of +154% over that period and showing compounded annual growth of +10%.

About 77% of U.S. solar jobs are in demand-side sectors such as installation, sales/distribution, and project development, according to the Solar Foundation. Meanwhile, manufacturing accounts for only about 13% of total solar jobs. About 5% of jobs are in solar operations and maintenance (O&M) and "other" solar sectors.

Those statistics illustrate how there are many more jobs in the installation side of solar in the U.S. than in solar manufacturing since the U.S. is a minor global producer of solar cells and panels.

The number of solar jobs in the U.S. exceeds those in the fossil fuel industries. Specifically, the 255,037 jobs in the solar sector far exceed the 124,600 direct jobs in the oil/gas extraction industry and 36,500 direct jobs in the coal mining industry at the end of 2021, 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.

