NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Spring 2022 Solar Industry Update

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Agenda

1. Global Solar Deployment
2. U.S. PV Deployment
3. PV System Pricing
4. Global Manufacturing
5. Component Pricing
6. Market Activity
7. U.S. PV Imports

Executive Summary

Global Solar Deployment

- In 2021, 172 GWdc of PV capacity was added globally, bringing cumulative capacity to 939 GWdc.
- China, the largest market, installed a record 55 GWdc (309 GWdc cumulative).
- Analysts project increased annual global PV installations over the next 4 years, with continued growth in China, the United States, Europe, and India.
- In 2021, approximately 250 MW of CSP was added in China and 110 MW in Chile.
- An additional 1.7 GW of CSP is currently under construction.

U.S. PV Deployment

- Over 35 GWac of new installed capacity was either from renewable energy (18.6 PV, 14.0 GW wind) or battery technologies (3.4 GW) in 2021, surpassing last year's record. PV alone represented 44% of new U.S. electric generation capacity.
- Solar still only represented 8.0% of net summer capacity and 3.9% of annual generation in 2021.
- However, 11 states generated more than 6% of their electricity from solar, with California leading the way at 25.0%.
- The United States installed 18.6 GWac (23.6 GWdc) of PV in 2021, ending the year with 92.5 GWac (119.7 GWdc) of cumulative PV installations.
- The United States installed approximately 10.6 GWh, 3.6 GWac of energy storage onto the electric grid in 2021, up 197% y/y.

A list of acronyms and abbreviations is available at the end of the presentation.

PV System and Component Pricing

- The median system price of utility-owned PV plant installed in 2021 was $1.20/Wac ($0.97/Wdc)—down 11% y/y in Wac but up 8% in Wdc.
- The median reported price by EnergySage for residential PV systems decreased 2.5% between the second half of 2020 and the second half of 2021 to $2.68/Wdc but increased between first and second half of 2021—the first reported increase on record.

Global Manufacturing

- In 2021, global PV shipments were approximately 194 GW (95% of which were mono c-Si technology)—an increase of 47% from 2020.
- In 2021, the United States produced a record 4.8 GW of PV modules, up 11% y/y, mostly as a result of a 25% increase in production by First Solar.

U.S. PV Imports

- On February 4, 2022, Section 201 tariffs on crystalline silicon modules and cells were extended for another 4 years at just below 15%. Bifacial modules will remain exempt as will be the first 5 GW of imported cells.
- On April 1, 2022, based on a petition from Auxin Solar, the U.S. Department of Commerce (Commerce) initiated an investigation into whether Chinese companies are circumventing antidumping and countervailing duties by manufacturing cells and modules in Southeast Asian countries.
- 23.6 GW of PV modules and 2.6 GW of PV cells were imported into the United States in 2021, 77% of which came from Malaysia, Vietnam, Thailand, and Cambodia.

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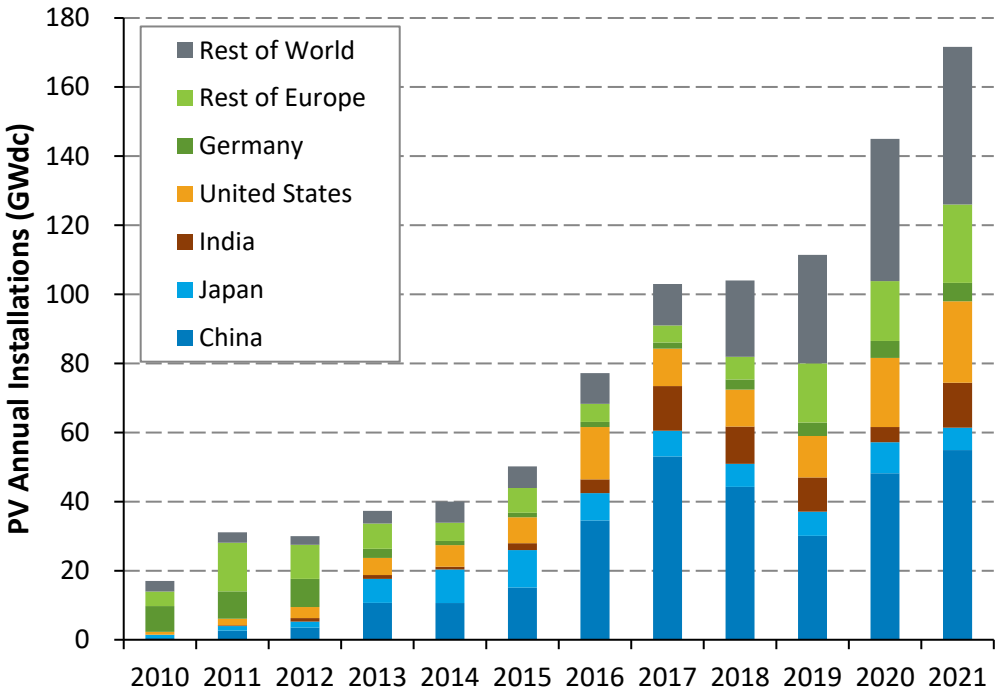
- **From 2010 to 2021, global PV capacity additions grew from 17 GWdc to 172 GWdc.**
  - At the end of 2021, global PV installations reached 939 GWdc.
- **In 2021, solar contributed 30% to new generation capacity in China (a record of 55 GWdc) and 13% of cumulative capacity (309 GWdc).**
  - China installed 13.2 GWdc in Q1 2022, a 148% increase, y/y.
- **Analysts project increased annual global PV installations over the next 4 years, with continued growth in China, the United States, Europe, and India.**
- **In 2021, approximately 250 MW of CSP was added in China and 110 MW in Chile.**
  - An additional 1.7 GW of CSP is currently under construction.

Global Annual PV Capacity Additions by Country



- From 2010 to 2021, global PV capacity additions grew from 17 GWdc to 172 GWdc.
  - In 2021, global PV installs increased 19%, y/y.
  - The total cumulative installed capacity for PV at the end of 2021 reached at least 939 GWdc.
- European markets led in the beginning of the decade, but PV growth then transitioned to Asia.
  - At the end of 2021, 57% of cumulative PV installations were in Asia, 21% were in Europe, and 16% were in the Americas.
- In 2021, the top 10 countries installed 74% of global installations.
  - At least 20 countries installed more than 1 GW of PV, and 15 countries now have more than 10 GW of cumulative PV.

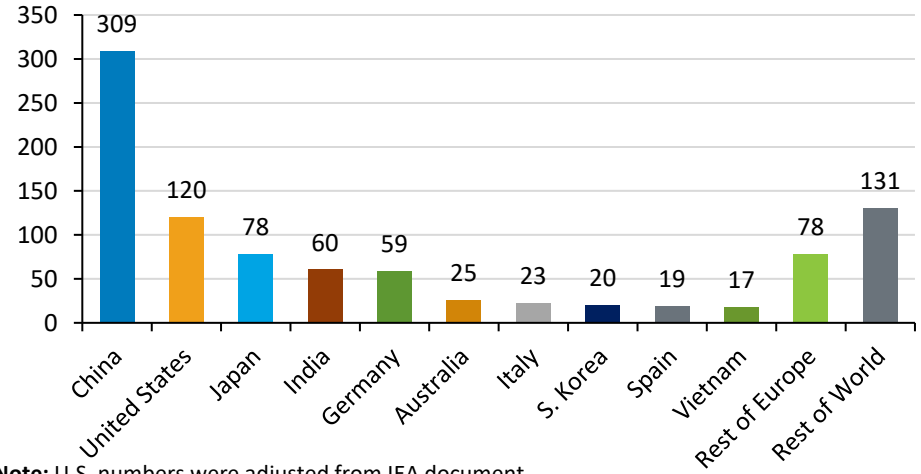
Sources: IEA, Snapshot of Global PV Markets: 2022; PVPS Snapshot 2020 and 2021; Trends in Photovoltaic Applications 2019.

Top PV Markets

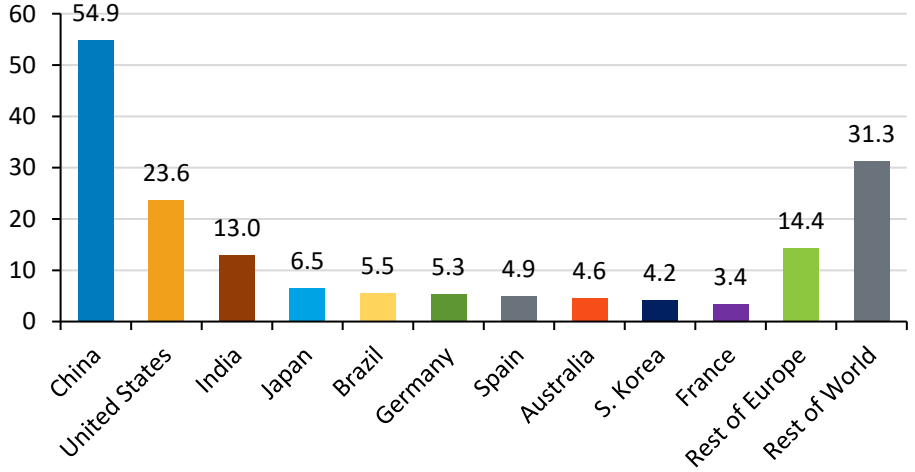
- The leading five markets in cumulative PV installations at the end of 2021 were China, the United States, Japan, India, and Germany.
  - Brazil just bumped Germany out of the top five for annual deployment.

- China's annual PV installations grew 14% y/y in 2021, representing just under one-third of annual global deployment.
- In 2021, the United States had the second-largest PV market in terms of both cumulative and annual installations.
  - The EU was the second-largest market, with 178.5 GWdc of cumulative installations (19% of global) and 26.5 GWdc annual installations (15% of global) in 2021.

Cumulative PV Deployment, 2021 (939 GWdc)



Annual PV Deployment, 2021 (172 GWdc)

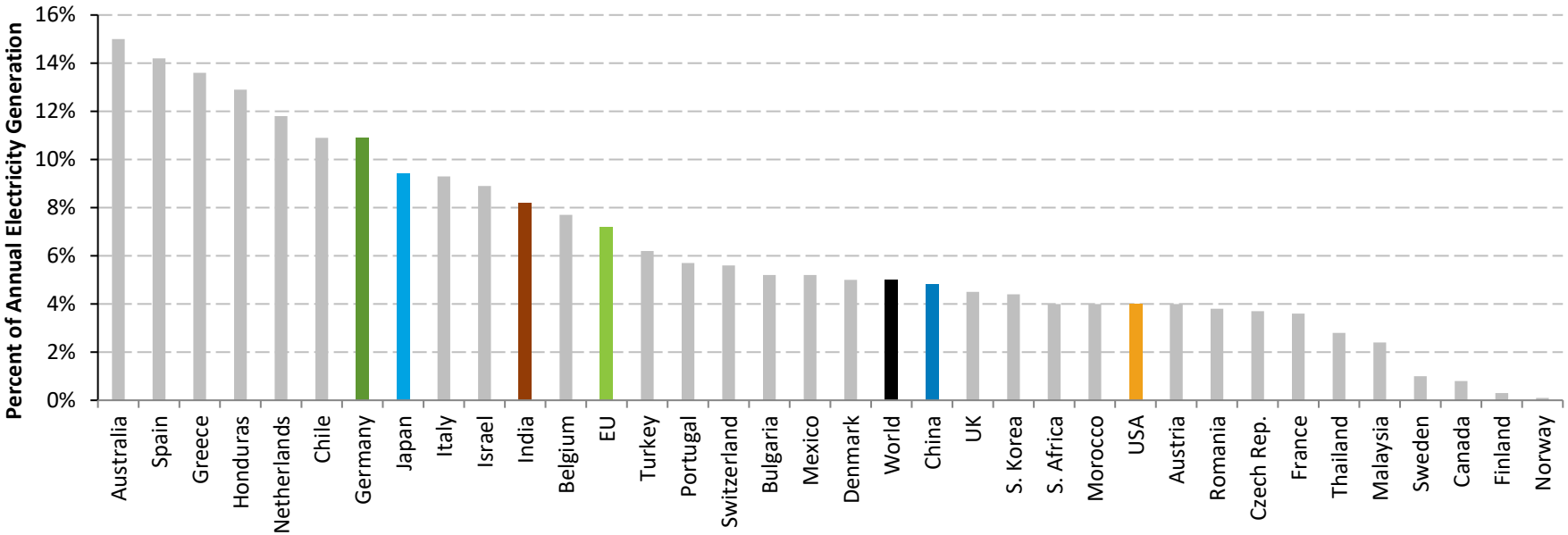


Note: U.S. numbers were adjusted from IEA document.
Sources: IEA, Snapshot of Global PV Markets: 2022; Wood Mackenzie/SEIA: U.S. Solar Market Insight: 2021 YIR.

Global PV Penetration

- IEA estimates that in 2021, 5% of global electricity generation came from PV.

- The United States, despite being a leading PV market, is below this average and other leading markets in terms of PV generation as a percentage of total country electricity generation, with 4%.
  - If California were a country, its PV contribution (25%) would be the highest.



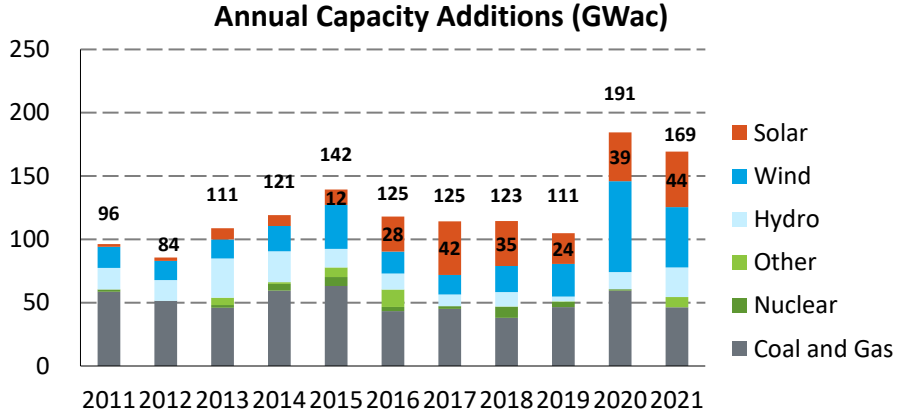
Source: IEA, Snapshot of Global PV Markets: 2022.

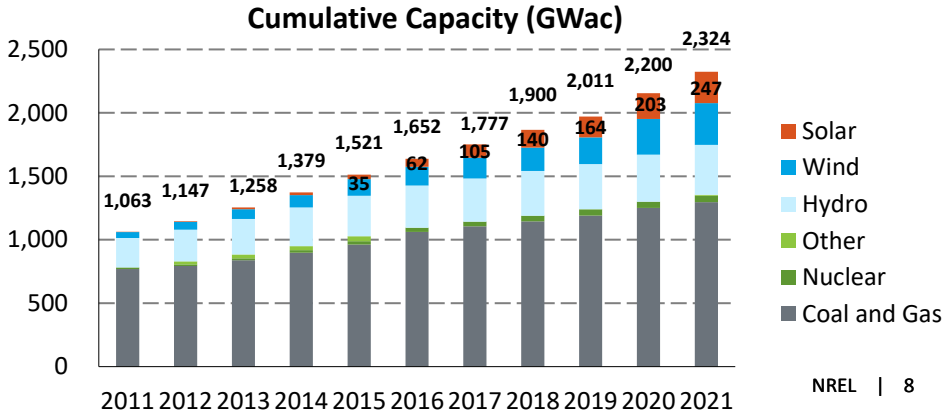
Chinese Generation Capacity Additions by Source

Note: IEA reports that China reports solar in Wdc. To align Chinese solar numbers with other generation sources, and how we represent U.S. total capacity additions, we converted solar values to Wac, using an ILR of 1.25.

Sources: China Electric Council, accessed (2017, 2018, 2019, 2020, 2021); China National Energy Administration (1/28/22); NASDAQ (1/26/22); Wind Power Monthly (1/27/22); BloombergNEF (1Q 2022 Global PV Market Outlook); IEA, Snapshot of Global PV Markets: 2022.

- In 2021, solar contributed 26% to new generation capacity in China (55 GWdc/~44 GWac) and 13% of cumulative capacity (309 GWdc/247 GWac).
  - Solar installed in 2021 surpassed the previous high of 42 GWac set in 2017.
  - In 2021, for the first time, more distributed solar (53%) was installed than utility-scale solar (47%).
  - Wind and solar accounted for 57% of the capacity installed in 2021—the fifth straight year they contributed more than half of capacity additions.
  - Coal and gas deployment has remained relatively flat over the past 11 years as renewables have grown.
- The share of capacity from renewables has increased as China's total electric capacity has grown.
  - China's capacity grew by 119% from 2011 to 2021.
  - During the same period, the percentage of total coal and gas capacity dropped from 72% to 56%.
  - New non-carbon generation capacity as a percentage of total new capacity increased from 39% to 68%.





Chinese Market Update

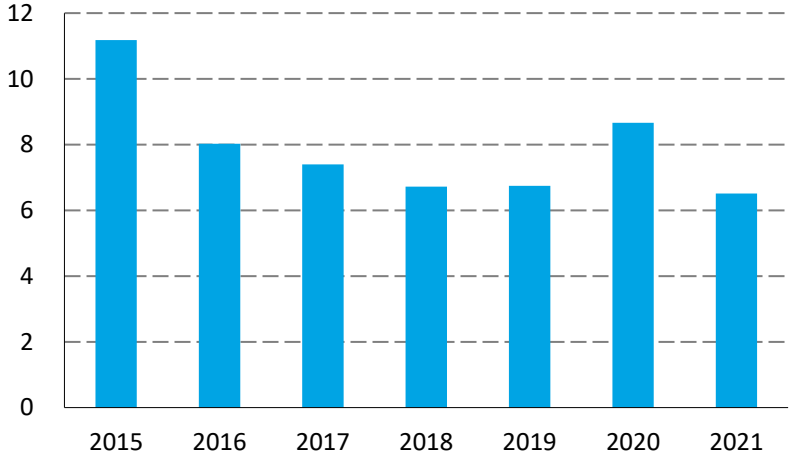
Sources: BloombergNEF (1Q 2022 Global PV Market Outlook); TaiyangNews (3/24/22); PV Magazine (2/25/22)

- Utility-scale PV is poised for growth in 2022, as projects delayed in 2021 owing to high equipment costs likely will be built in 2022, and more gigawatt-scale "mega energy bases" are scheduled for construction.
  - China installed 13.2 GWdc in Q1 2022, a 148% increase, y/y.
- New rooftop PV systems will not receive subsidies, but distributed PV deployment will be encouraged by China's small-scale PV bulk development model, rising commercial and industrial electricity prices, and new energy consumption control policies.
  - Distributed PV growth could be hampered in the medium term by the need to upgrade distribution infrastructure.
- China's central government asked state-owned independent power producers (IPPs) in late 2021 to achieve a renewables capacity share of 50% or higher by 2025.
  - IPPs must balance this goal against profitability mandates, which, in light of higher equipment prices, likely will result in variable progress toward the renewables target.
- China's green hydrogen and energy storage goals complement renewables-driven decarbonization goals.
  - China announced a goal of up to 200,000 million tons of hydrogen from solar and wind annually by 2025.
  - State Grid Corporation of China, which operates 80% of China's electricity grids, announced a goal of 100 GW of battery storage and 100 GW of pumped storage hydropower by 2030.

Japanese Market Update

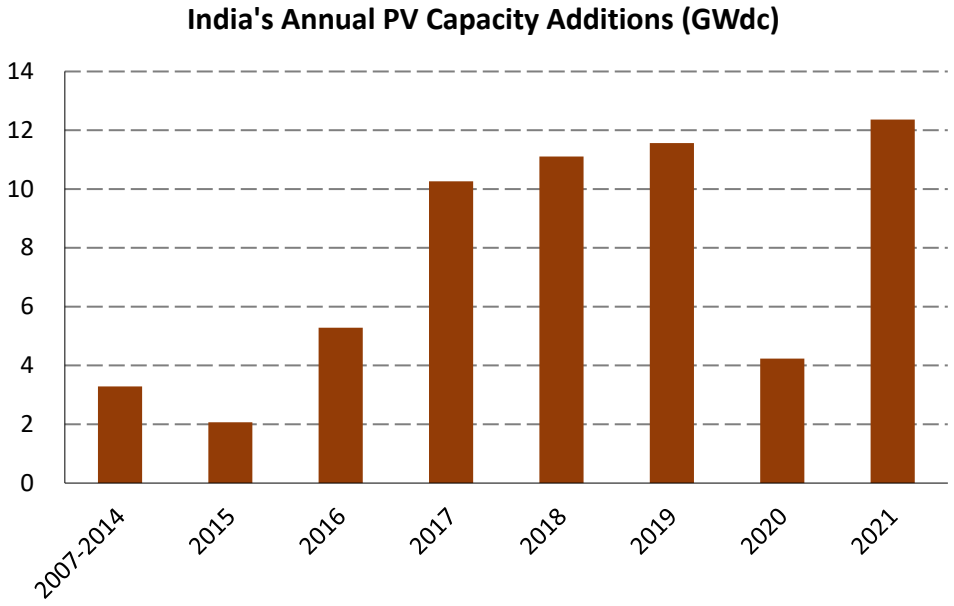
- Japan installed about 6.5 GWdc of PV in 2021—down 25% from a relatively high-installation year in 2020—resulting in about 78 GWdc of cumulative capacity.
- Achieving Japan's goal of carbon neutrality by 2050 may require 370 GWdc of PV by 2050.
  - In late 2021, Japan raised its target for renewable electricity generation in 2030 from 22%–24% to 36%–38%, which is projected to include about 108 GWdc of PV by 2030.
  - Because of scarce land and the difficulty of deploying PV on earthquake-proof residences, deployment targets include water bodies, government and commercial buildings, car parks, and farms.
- Japan proposed modest feed-in tariff levels for 2022 of $0.15/kWh for systems < 10 kW, $0.096/kWh for 10–50 kW systems, and $0.087/kWh for 50–250 kW systems
  - These levels will not make PV profitable at current construction costs, which may result in only 3 GW being installed in 2022, said one analyst.

Japan's Annual PV Capacity Additions (GWdc)



Sources: BloombergNEF (1Q 2022 Global PV Market Outlook); PV Magazine (7/23/21, 2/24/22); International Renewable Energy Agency (Solar Energy Data, 3/4/22); TaiyangNews (12/21/21, 12/22/21); PV Tech (7/7/21, 10/25/21). Photo (Panoramic view of a 1.5 MWdc floating solar system in Japan, 2017) by Adam Warren/NREL.

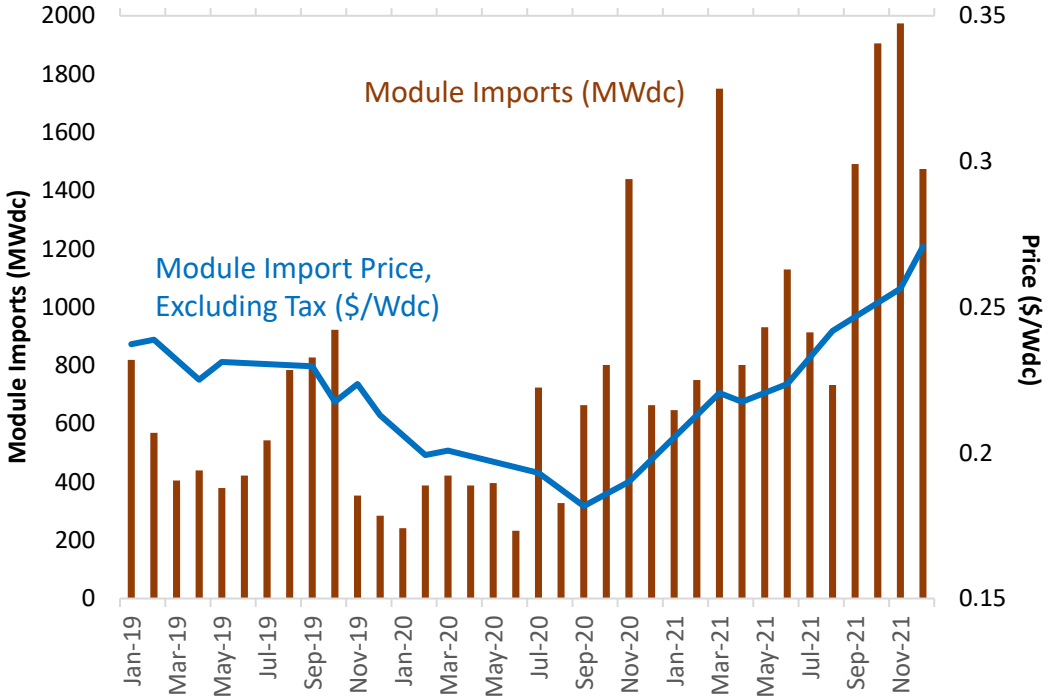
Indian Market Update



- After a pandemic-driven decline to 3.2 GWac in 2020, India's solar deployment surged 210% to an all-time high of 10 GWac in 2021.
  - Projects delayed in 2020 fueled 2021 growth.
  - Large-scale projects accounted for 83% of 2021 installations and rooftop systems accounted for 17% of them.
  - Solar made up 62% of total new electric generation capacity installed.
- At year-end 2021, cumulative solar installations reached 49 GWac, which is equivalent to 12% of total power capacity and 32% of renewable capacity.
- The large-scale solar pipeline totaled 53 GWac.

Sources: BloombergNEF (1Q 2022 Global PV Market Outlook); Mercom India Research (Q4 & Annual 2021 India Solar Market Update); PV Magazine (2/28/22).

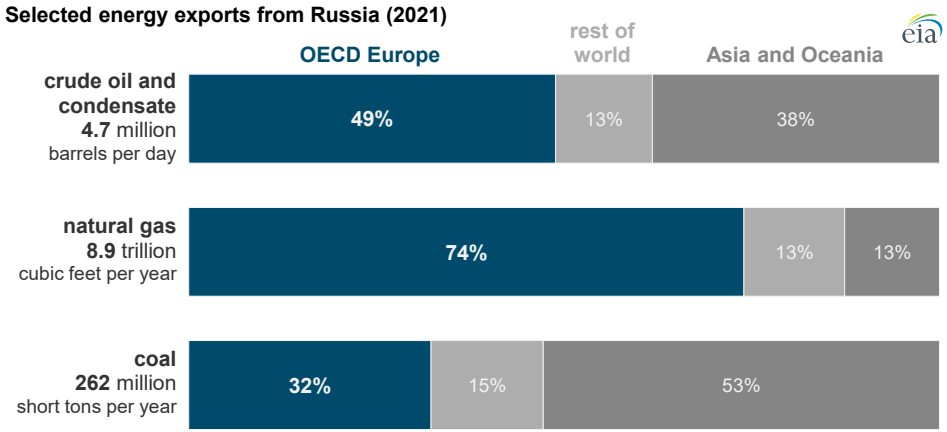
Indian Market Update



- India's 2021 growth occurred despite rising costs.
  - in Q4 2021, large-scale PV project prices rose 21.6% and rooftop PV prices rose 14.8% y/y.
  - Imported module prices rose 14% in 2021.
- Module imports accelerated to exploit an 8-month zero-import-tax period that began in August 2021, ahead of a basic customs duty—40% for modules, 25% for cells—starting in April 2022.
- Concerns have been raised about the impacts of a basic customs duty on price and availability delaying PV projects.
- India's Approved List of Models and Manufacturers is meant to boost domestic module manufacturing by constraining imports over time.
- A $3.2 billion, 5-year subsidy program is stimulating Indian polysilicon, wafer, cell, and module production. BNEF estimates that module and cell production capacity could reach 36 and 18 GW by end of 2023.

Sources: BloombergNEF (1H 2022 India Renewables Market Outlook); PV Tech (3/9/22, 3/11/22); PV Magazine (3/15/22).

Europe and Russia Depend on Each Other Due to Energy



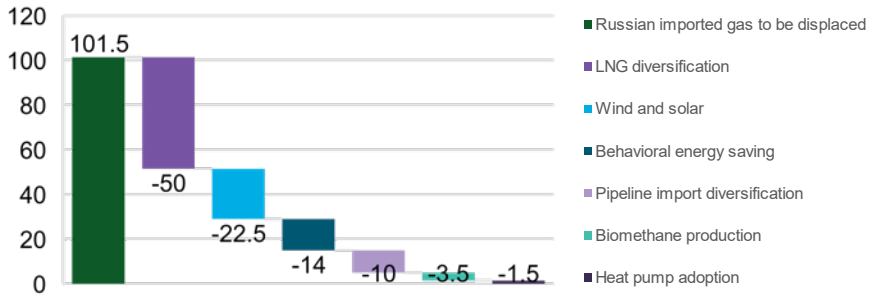
- In 2019, more than half of Russia's exports was fuel.
- Most of the energy Russia exports goes to Europe.
  - Energy accounted for nearly two-thirds of EU's imports from Russia in 2021 and 40% of Europe's natural gas comes from Russia.
    - Approximately 1/3 of EU natural gas consumption is used for electricity, another 1/3 is used for residential and commercial buildings, and 27% goes to industry.
  - Germany is particularly dependent on Russia, with half of its natural gas and coal coming from Russia.
  - In contrast, 8% of U.S. imported oil, or 2% of supply, comes from Russia.

Sources: AP News (11/17/21); EIA (03/14/22); EuroNews (02/25/22); NBC News (03/09/22); Reuters (02/28/22, 03/07/22);World Bank.

Russian Invasion of Ukraine Prompts Changes to European Energy Mix

- On March 8, 2022, The European Commission released a plan to cut Russian gas imports by two-thirds in 2022 and all oil, gas, and coal by 2027.
  - Half the 2022 cuts will come from imports from elsewhere, and the rest will rely on renewable energy deployment and behavioral energy savings.

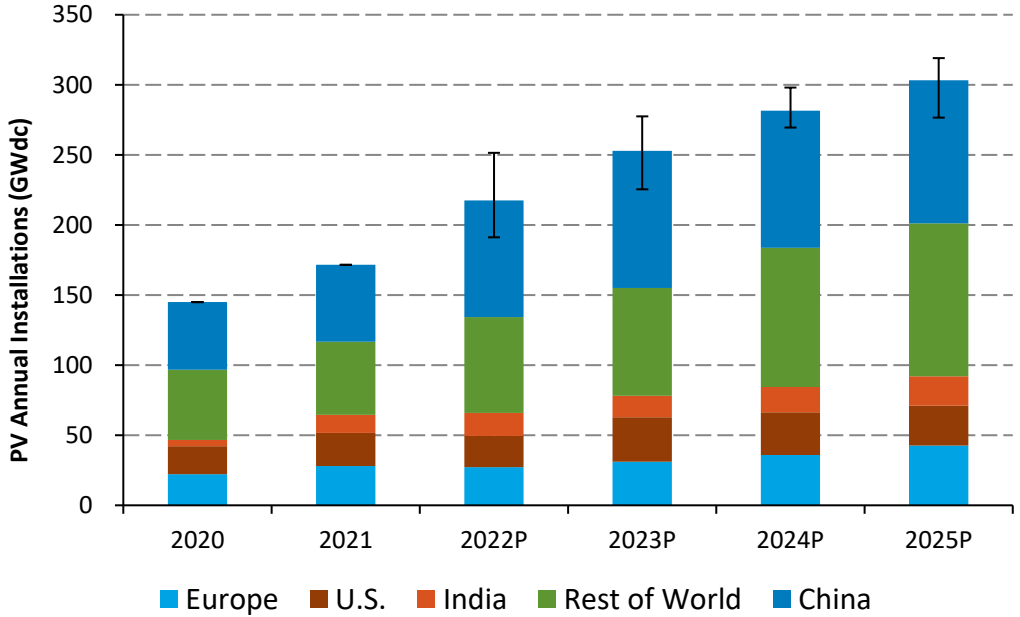
EU Targets for Russian Gas Imports to be Displaced in 2022 by Sectoral Targets



Source: BNEF, "Europe Plans Break from Russian Gas; European Commission (03/08/22); Reuters (02/28/22).

- LNG, with the United States being a key supplier, is an essential element of the plan, but in the short term there are limitations to LNG export (U.S.) and import facilities.
- The plan calls for doubling solar and wind capacity by 2025 and tripling it by 2030—the equivalent of deploying 480 GW of wind and 420 GW of solar capacity and increasing average deployment rate 20%.
  - It also calls for 12–15 GW of additional rooftop solar demand in 2022, which is roughly double BNEF's current forecast.
  - Green hydrogen and electrification (e.g., heat pumps) will also encourage solar adoption.
  - There is also a proposal to temporarily allow states to recoup "windfall" profits from wind and solar operators to lower energy costs to consumers.
- Switching from Russian natural gas in the short term may increase coal and nuclear production, particularly in Germany, which had planned to phase nuclear out by 2022 and coal by 2030.
  - Also, Germany released a plan in late February to get 100% of its electricity from renewables by 2035.

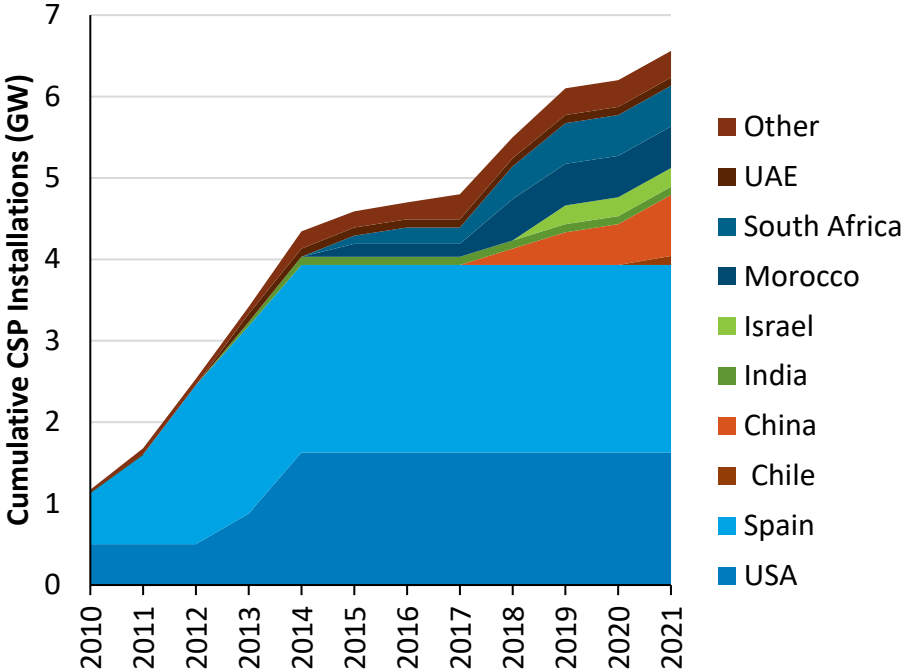
Annual Global PV Demand



Notes: P = projection. Bars represents median projections for country-level estimates. Error bars represent high and low projections. Not all sources have data for all categories.
Sources: BNEF, 1Q 2022 Global PV Market Outlook, 3/1/22; Goldman Sachs Equity Research, Americas Clean Technology: Solar 2021 Outlook, 01/09/22; Goldman Sachs Equity Research, Americas Clean Technology: Solar, Assessing the Impact of Volatile Macro - Oil, Commodities & EU in Focus, Raise Demand View Thru 2025, 3/29/22; Wood Mackenzie and SEIA's US Solar Market Insight, 2021 Year in Review, 3/22; U.S. Energy Information Administration, Annual Energy Outlook, 3/3/22; IEA, Snapshot of Global PV Markets: 2022.

- About 172 GWdc of PV were installed globally in 2021.
- Analysts project continued increases in annual global PV installations, with the growth rate slowing over time.
  - 218 GWdc in 2022 (27% y/y growth)
  - 253 GWdc in 2023 (16%)
  - 282 GWdc in 2024 (11%)
  - 303 GWdc in 2025 (8%)
- Among analysts who updated global projections since last quarter, global estimates increased significantly (e.g., by 12%–21% in 2025).
- China, Europe, the United States, and India are projected to account for about two-thirds of global PV installations over this period.
- Projected U.S. deployment growth is relatively stagnant during this period, declining in 2022, growing in 2023, and then declining again in 2024 and 2025.

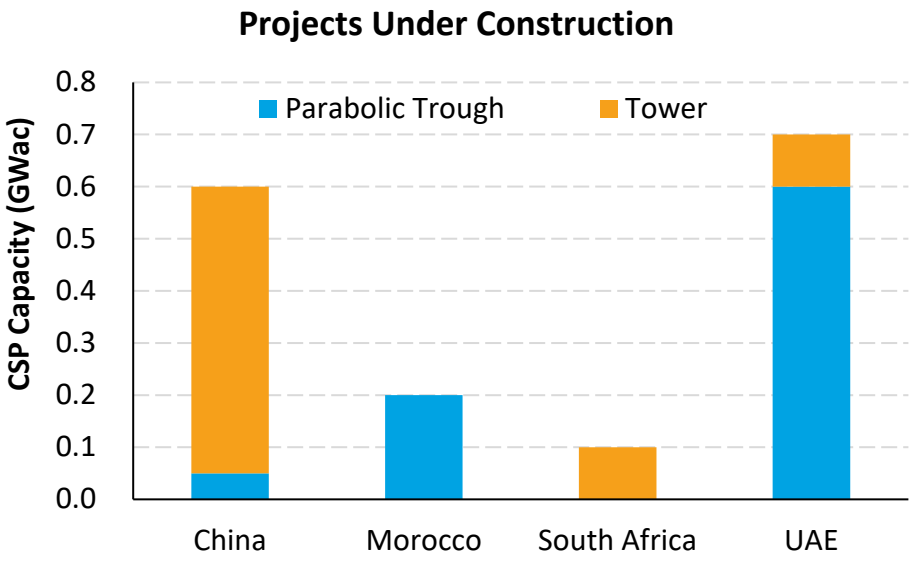
Current Global CSP Capacity



- At the end of 2021, global CSP capacity reached approximately 6.6 GW.
- Cumulative global CSP installations were almost six times higher in 2021 than in 2010.
  - Initially most of the growth came from Spain (first-largest) and the United States (second-largest).
- From 2015 to 2021, 2.6 GW of CSP was installed in other parts of the world, particularly the Middle East, North Africa, South Africa, and China.
  - There was also development in other parts of the world, such as India and South America.
- In 2021, 250 MW of CSP started operation in China and 110 MW began in Chile.
  - All projects used power tower technology.
  - Molten salt storage durations ranged from 8 hours to 17.5 hours.

Sources: The World Bank (2021); Ren21 (2021); NREL.

Global CSP Pipeline



- Approximately 1.7 GW of CSP is currently under construction in four countries, using a mix of trough and tower technology.
  - The projects all have 5–15 hours of thermal energy storage.
- In addition to these projects, another ~10 GW of CSP is in some stage of development, though its prospects of reaching commercial operation are unclear.
  - Many of these projects are in Chile, China, the Middle East, and South Africa.

Note: Timelines vary by the circumstances of individual CSP projects, but each step can take two years, or six years in total.

Sources: The World Bank (2021); HeliosCSP (02/28/22, 03/24/22, 04/07/22); BNEF, "Capacity & Generation" data set, accessed March 1, 2022.

Using CSP for Industrial Process Heat

- In the United States, there have been recent additions (e.g., 2.3 MWth solar steam boiler for almond pasteurization in California and solar water heating in New York).
- In Spain, companies built a pilot plant to produce cement using direct solar heat instead of fossil fuels. Cement is one of the most carbon-intensive industries, globally.
- An Australian oil and gas producer purchased 5 MWe of Heliogen equipment for a demonstration project in the Mojave Desert, with the aim of producing green hydrogen, aiding in oil and gas extraction, or producing electricity in Australia and elsewhere.

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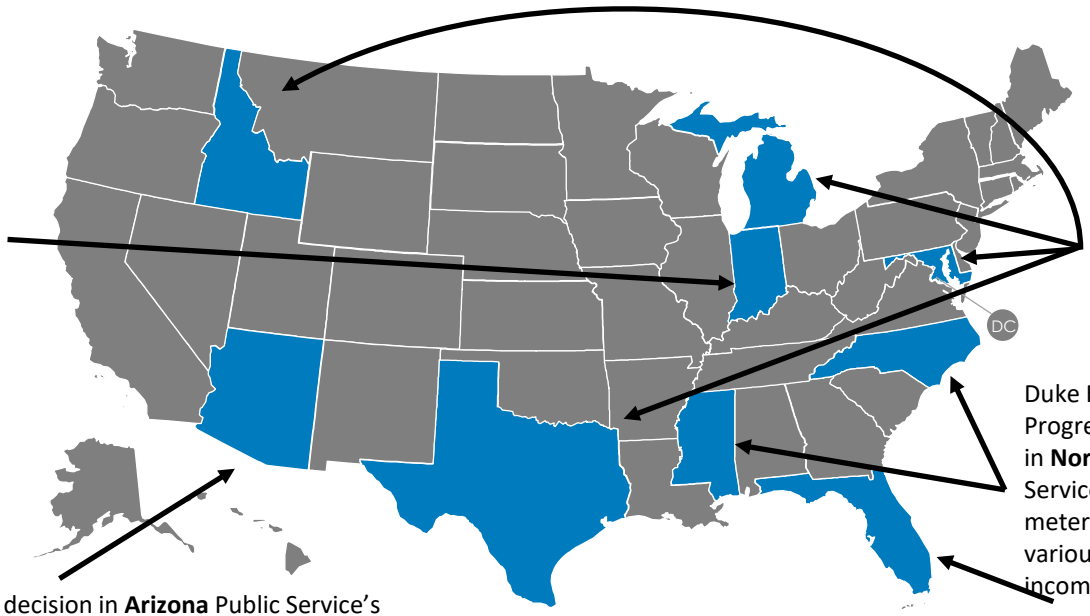
- **In 2021, PV represented approximately 44% of new U.S. electric generation capacity, compared to 4% in 2010.**
  - Over 35 GWac of new installed capacity was either from renewable energy or battery technologies in 2021, surpassing last year's record.
- **Solar still represented only 8.0% of net summer capacity and 3.9% of annual generation in 2021.**
  - However, 11 states generated more than 6% of their electricity from solar, with California leading the way at 25.0%.
- **The United States installed 18.6 GWac (23.6 GWdc) of PV in 2021, ending the year with 92.5 GWac (119.7 GWdc) of cumulative PV installations.**
- **The United States installed approximately 10.6 GWh, 3.6 GWac of energy storage onto the electric grid in 2021, up 197% y/y.**

Q4 2021/Q1 2022 State Updates

Many states took actions related to distributed generation compensation policies, including considering changes to credit rates, the creation of net metering successor tariffs, and the implementation of rebates.

Some states are also working to calculate the exact value of solar or DG, while others are assessing the costs and benefits of their existing net metering rules.



The **Indiana** Court of Appeals found that Vectren's recently approved net metering successor tariff utilizing instantaneous netting is in conflict with Indiana's distributed generation statute.

A working group formed by the **Michigan** Public Service Commission released its final report, which identified three potential rate designs for distributed energy resources. Pedernales Electric Cooperative approved changes to its net metering rates, following the release of its value of solar study. Idaho and Maryland also began studies into the value/cost of DER.

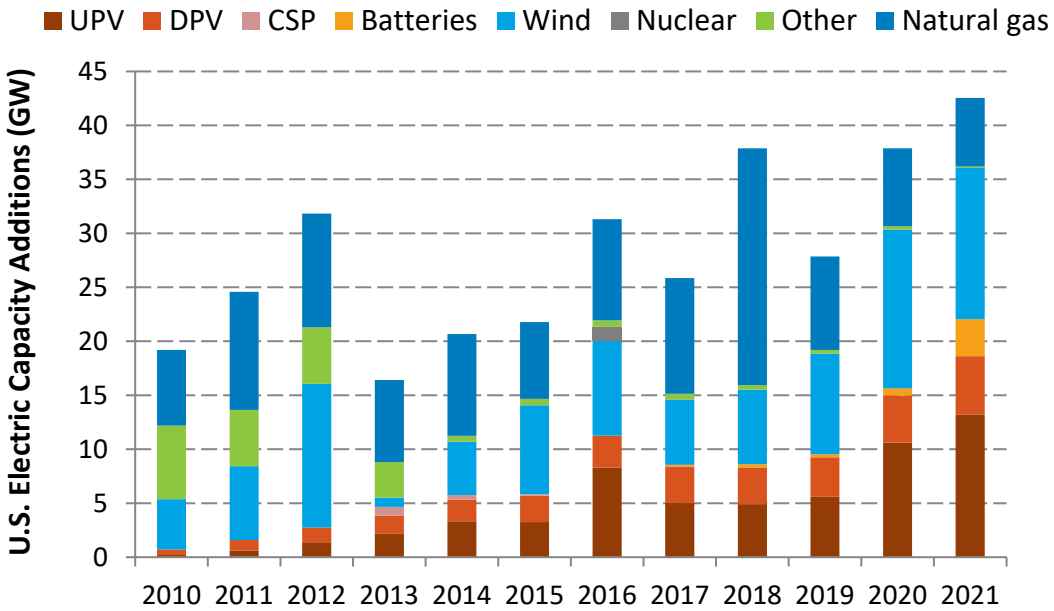
Duke Energy Carolinas and Duke Energy Progress proposed revised net metering tariffs in **North Carolina**. And **Mississippi** Public Service Commission released proposed net metering rule revisions. Thesproposals include various solar rebate programs (including low-income programs).

As part of a November 2021 decision in **Arizona** Public Service's general rate case, the Arizona Corporation Commission removed the utility's existing grid access charge for distributed solar customers participating in the TOU-E tariff (time-of-use rates with no demand charges).

In March 2022, The **Florida** Legislature passed House Bill 741 which, starting in 2023, would regress payments to solar customers from a retail rate to the "avoided cost" to the utility by 2029. The bill also allows for fixed charges for grid connected solar customers starting in 2026. In April, the governor vetoed the bill, citing the "financial crunch" it would have put on people in the state.

Source: Meister Consultants Group, *50 States of Solar: Net Metering Quarterly Update* (Q4 2021, Q1 2022), pv magazine: Florida House Bill 741.

New U.S. Capacity Additions, 2010–2021



- In 2021, PV represented approximately 44% of new U.S. electric generation capacity (31% UPV, 13% DPV), compared to 4% in 2010.
  - Wind represented 33% of added capacity.
  - Since 2017, PV has represented approximately 35% of new electric generation capacity.
- Over 35 GWac of new installed capacity was either from renewable energy or battery technologies in 2021, surpassing last year's record and nearly matching the total U.S. capacity additions in 2020 and 2018.
- Combined with wind, 77% of all new capacity in 2021 came from renewable sources.
- Battery installations jumped by a factor of 5 from 2020 to 2021; it now represents 8% of capacity additions.

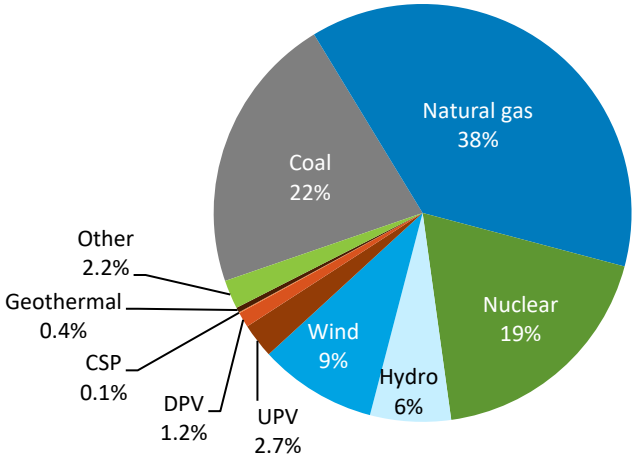
Note: "Other" includes coal, geothermal, landfill gas, biomass and petroleum. DPV = Distributed PV; UPV = Utility-scale PV
Sources: EIA, "Electric Power Monthly" Tables 6.1, 6.2B, 1.1, 1.1A; Forms 860M & 861M. April 2022.

2021 U.S. Generation and Capacity

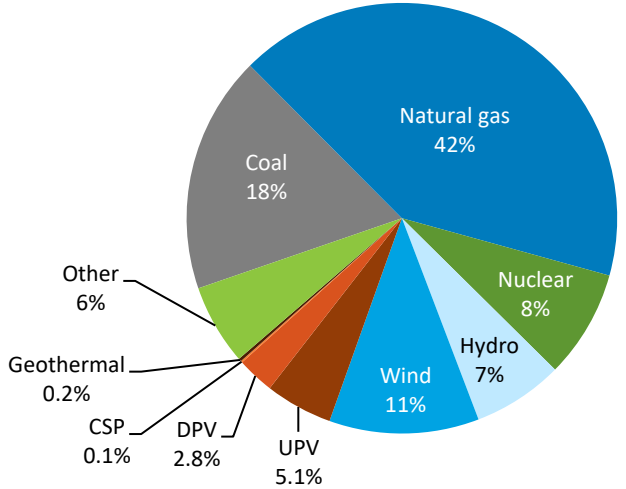
- Renewables are becoming an increasingly large part of the U.S. electric generation mix, representing 27% of capacity and 21% of generation in 2021.
  - Adding nuclear, non-carbon sources represented 35% of capacity and 40% of generation.

- Solar still represents a small but growing percentage of the U.S. electric generation mix.
  - In 2021, solar represented 8.0% of net summer capacity and 3.9% of annual generation.
- Capacity is not proportional to generation, as certain technologies (e.g., natural gas) have lower capacity factors than others (e.g., nuclear).

2021 U.S. Generation (Total 4,165 TWh)

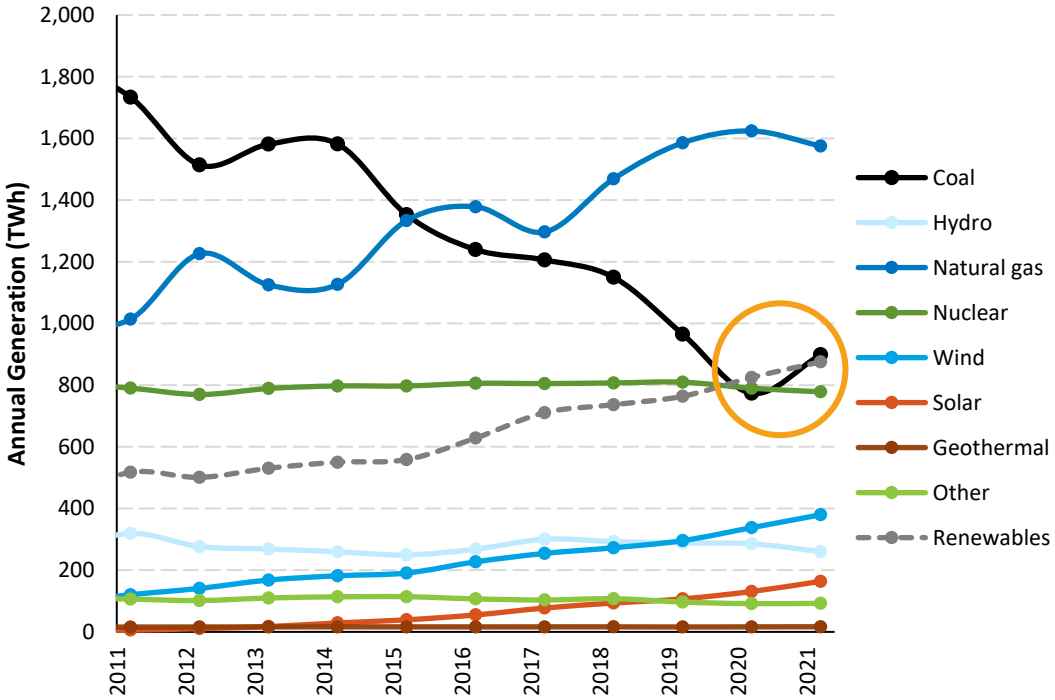


2021 U.S. Generation Capacity (Total 1.2 TW)



Sources: EIA, "Electric Power Monthly" Tables 6.1, 6.1A, February 2022, "Electricity Data Browser," April 5, 2022.

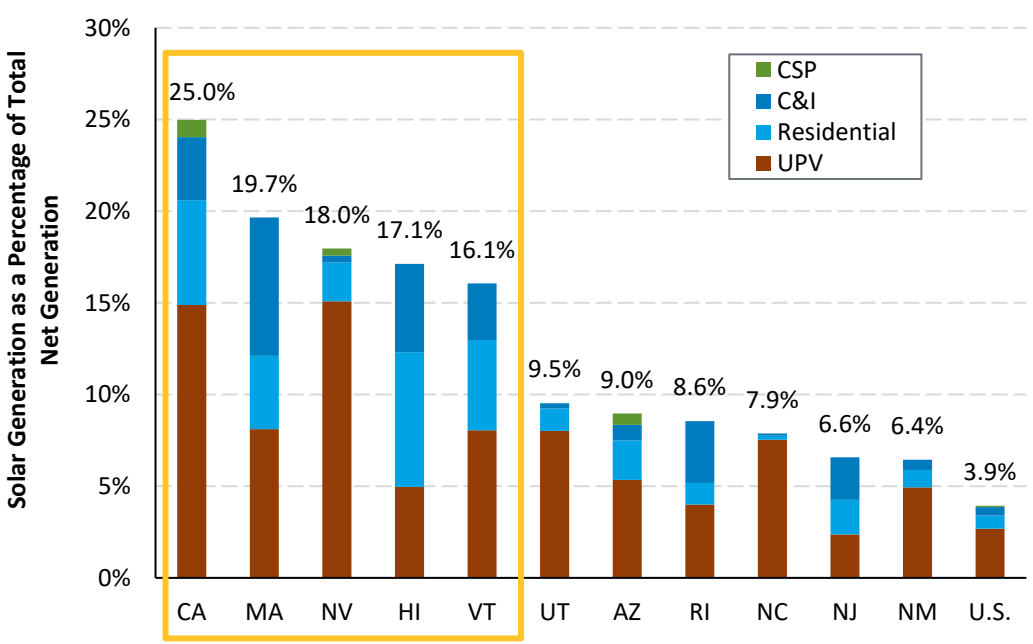
U.S. Generation, 2011–2021



- Energy generation from coal trended upward in 2021 for the first time since 2014, just barely exceeding total renewable generation, while generation from natural gas trended down for the first time since 2017.
  - The percentage of electricity generated by fossil fuels in the United States dropped from 68% in 2011 to 60% in 2021, while the percentage of electricity generated by renewable generation increased from 13% to 21% over the same period.
  - EIA attributed the increase in coal-fired electricity generation to increased U.S. natural gas prices, relatively stable coal prices, and increased energy demand.
- In 2021, renewable energy facilities continued to produce more electricity than nuclear sources.
- Generation from solar and wind both continued to increase, while generation from hydropower and nuclear sources continued to decrease.

Sources: U.S. Energy Information Administration (EIA), "Electricity Data Browser." Accessed April 5, 2022; Reuters (10/18/21).

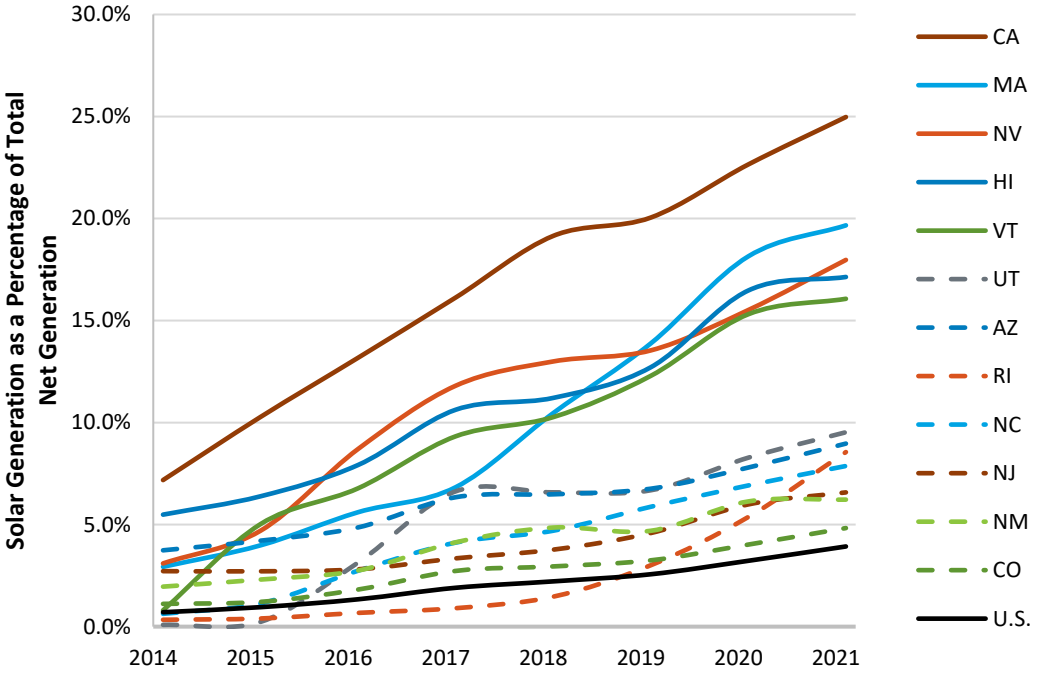
Solar Generation as a Percentage of Total Generation, 2021



Note: EIA monthly data for 2021 are not final. Additionally, smaller utilities report information to EIA on a yearly basis, and therefore a certain amount of solar data has not yet been reported. "Net Generation" includes DPV generation. Net generation does not take into account imports and exports to and from each state, and therefore the percentage of solar consumed in each state may vary from its percentage of net generation.
Source: U.S. Energy Information Administration (EIA), "Electricity Data Browser." Accessed February 28, 2022.

- In 2021, 11 states generated more than 6% of their electricity from solar, with California leading the way at 25.0%.
  - Five states generated more than 16% of their electricity using solar.
  - Nationally, 3.9% of electricity was generated from solar.
- The role of utility versus distributed solar varies by state, with northeastern states and Hawaii relying more on DPV.
  - Northeastern states also tend to have a greater proportion of their DPV coming from C&I, although it is still fairly even.

Solar Generation as a Percentage of Total Generation, 2014–2021



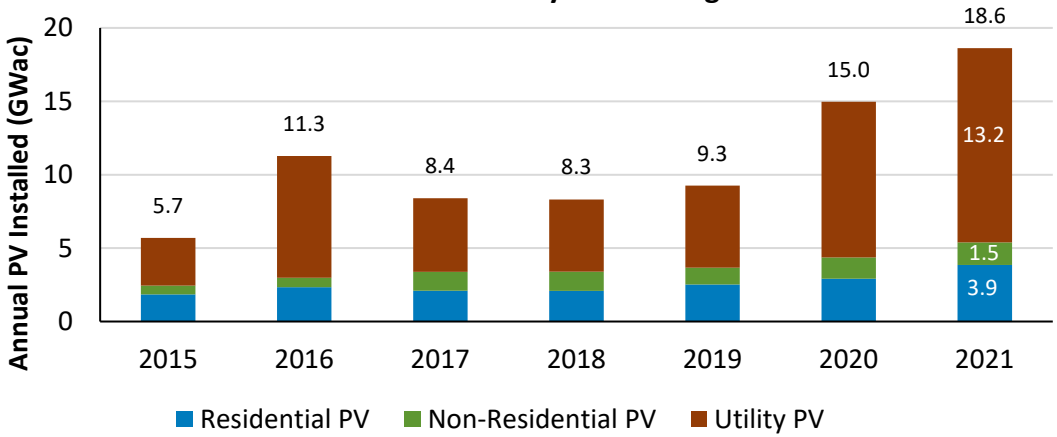
- From 2014 to 2021, leading solar deployment states greatly increased solar electricity penetration.
- In the past 5 years, five states (solid lines) shifted over 9% of their electricity generation to solar sources.
  - Some of the increase in Massachusetts's percentage is due to significant reduction in total electricity production within the state.
- The United States, as a whole, has a much lower levels, but it has still increased generation by 458% since 2014.

Note: EIA monthly data for 2021 are not final. Additionally, smaller utilities report information to EIA on a yearly basis, and therefore a certain amount of solar data has not yet been reported. "Net Generation" includes DPV generation. Net generation does not include imports and exports to and from each state, and therefore the percentage of solar consumed in each state may vary from its percentage of net generation.
Source: U.S. Energy Information Administration (EIA), "Electricity Data Browser." Accessed April 5, 2022.

U.S. Installation Breakdown Annual: EIA (GWac)

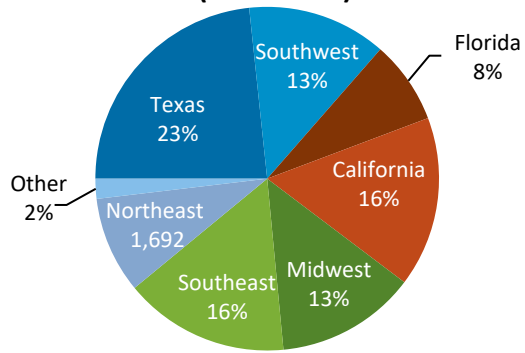
- Despite the impact of the pandemic on the overall economy, the United States installed 18.6 GWac of PV in 2021, its largest total ever—up 24% y/y.
  - Residential (3.9 GWac), C&I (1.5 GWac), and utility-scale PV (13.2 GWac) were up 32%, 5%, and 25%, respectively, in 2021.

U.S. PV Installations by Market Segment



- Approximately 47% of U.S. PV capacity installed in 2021 was in Texas, Florida, and California.
- Despite a concentration of PV installations in the top three markets, diversification of growth continues across the United States.
  - 19 states had more than 1 GWac of cumulative PV installations at the end of 2021 (New Mexico and Illinois both achieved this distinction for the first time in 2021), and 25 states installed more than 100 MWac in 2021.

2021 U.S. PV Installations by Region (18.6 GWac)

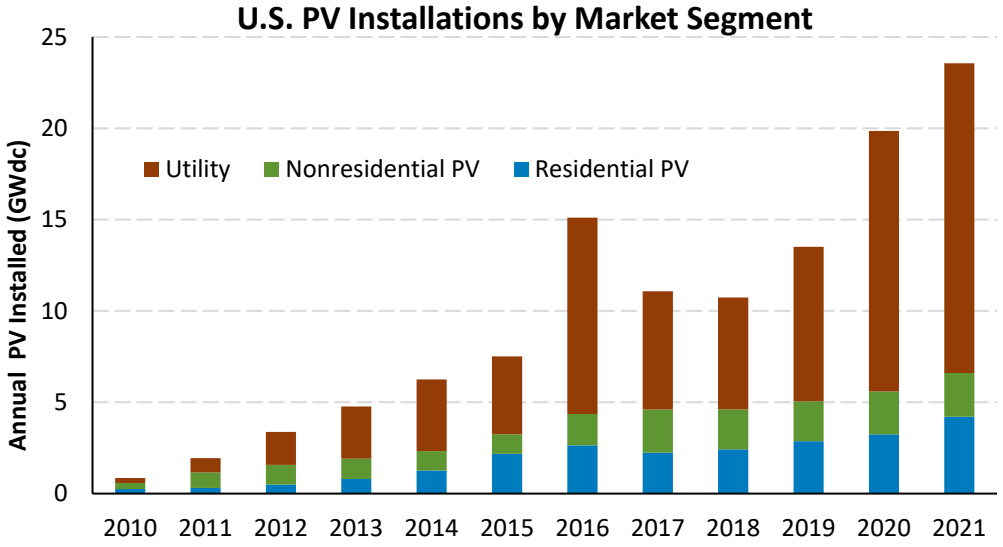


Note: EIA reports values in Wac which is standard for utilities. The solar industry has traditionally reported in Wdc. See the next slide for values reported in Wdc.
Sources: EIA, "Electric Power Monthly," forms EIA-023, EIA-826, and EIA-861 (April 2022, February 2021, February 2019).

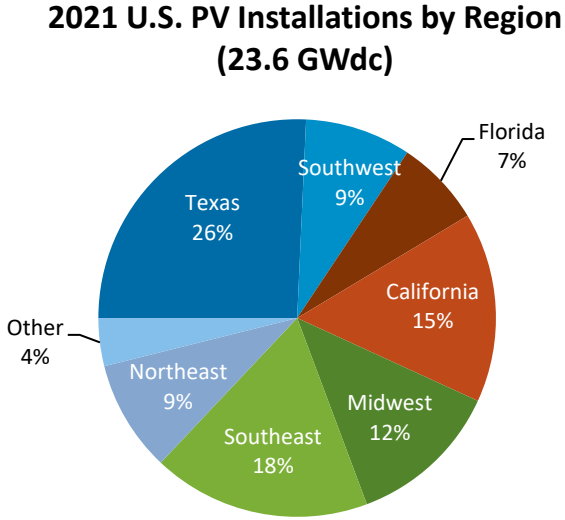
U.S. Installation Breakdown Annual: SEIA (GWdc)

Unlike the previous slide, these values are in GWdc—not GWac.

- SEIA reports that the United States installed 23.6 GWdc of PV in 2021 (119.7 cumulative)—an annual increase of 19% y/y.
  - 16.7 GWdc UPV (19% y/y), 2.4 GWdc Non-residential (2% y/y), and 4.2 GWdc Residential (30% y/y).
- Q4 2021 installations totaled 7.8 GWdc.



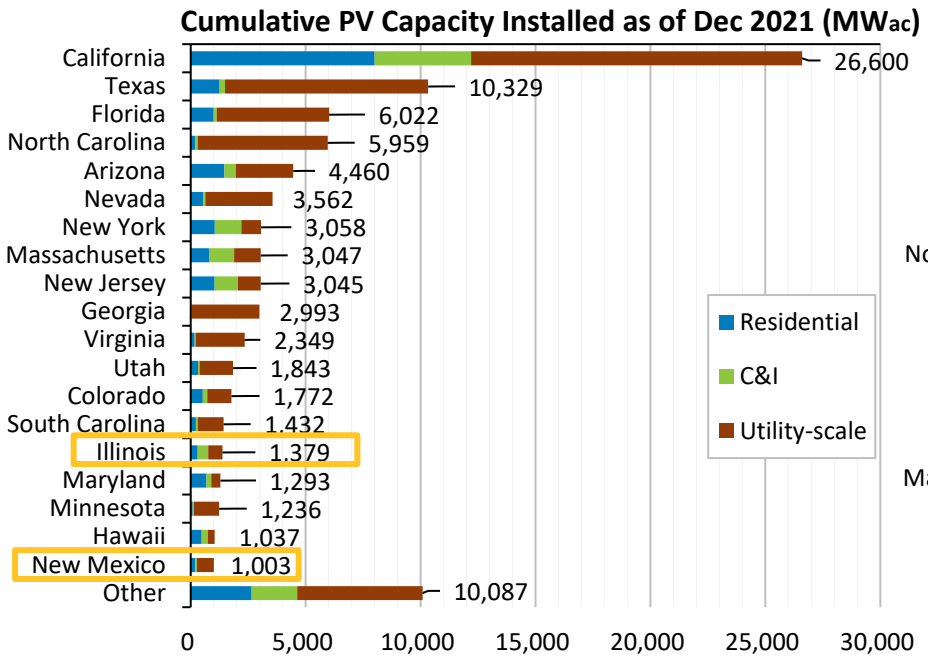
- Six states installed more than 1 GWdc of PV in 2021, and 22 states have more than 1 GWdc of cumulative PV installations (Connecticut, Indiana, Illinois, and Oregon all achieved this distinction for the first time in 2021).
- Texas installed over 6 GWdc in 2021 alone.

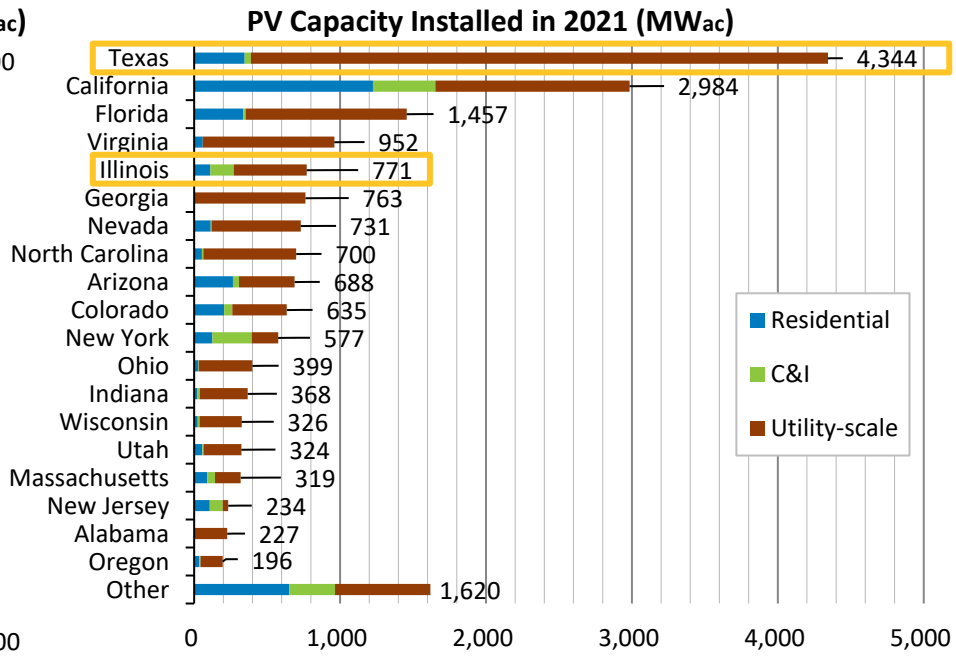


Sources: Wood Mackenzie/SEIA: U.S. Solar Market Insight: 2021 YIR.

U.S. Installation Breakdown by State

At the end of 2021, there were 92.5 GWac of solar PV systems in the United States, of which 59.5 GW were utility-scale PV, 21.0 GW were residential PV, and 11.9 GW were C&I PV.



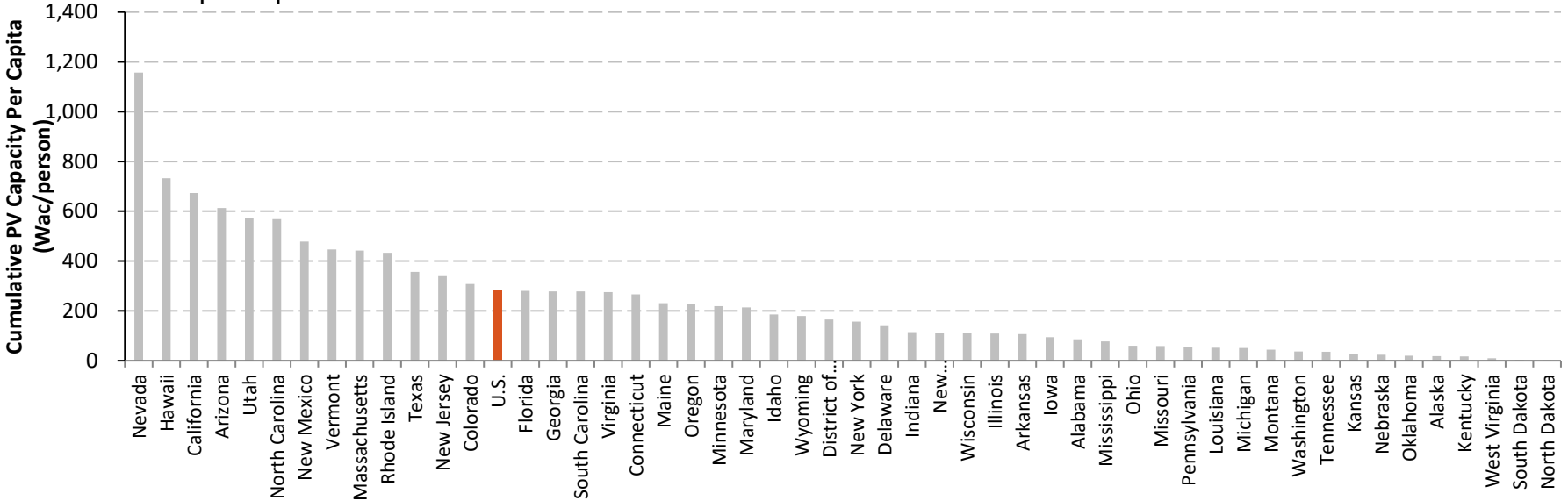


Note: EIA monthly data for 2021 are not final. Additionally, smaller utilities report information to EIA on a yearly basis, and therefore, a certain amount of solar data have not yet been reported. "Net Generation" includes DPV generation. Virginia's C&I installations in 2021 were net negative.

Sources: EIA, "Electric Power Monthly," forms EIA-023, EIA-826, and EIA-861 (February 2022, February 2021).

Cumulative U.S. PV Capacity Per Capita (2021)

- Some large states that ranked high in total cumulative capacity at the end of 2021, such as Texas (#2), Florida (#3) and New York (#7), are noticeably lower in rankings on a watts per capita basis. Texas drops to #11, Florida to #14, and New York to #26.
  - Conversely, Nevada and Hawaii, which ranked 6th and 18th in cumulative PV capacity, jump to 1st and 2nd in terms of PV watts per capita.



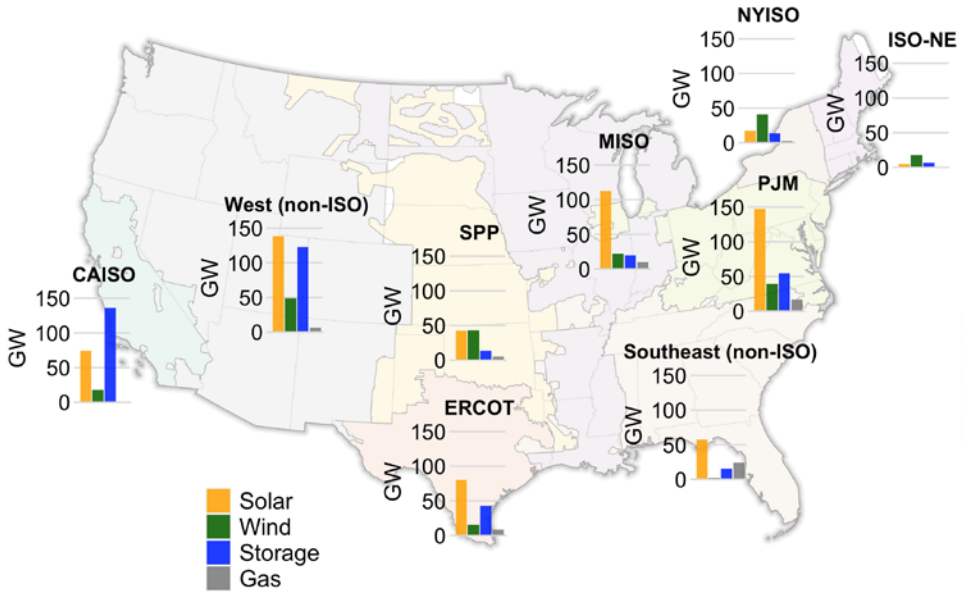
Note: EIA monthly data for 2021 are not final. Additionally, smaller utilities report information to EIA on a yearly basis, and therefore, a certain amount of solar data have not yet been reported. "Net Generation" includes DPV generation. Virginia's C&I installations in 2021 were net negative.

Sources: EIA, "Electric Power Monthly," forms EIA-023, EIA-826, and EIA-861 (February 2022, February 2021); United States Census Bureau (2019).

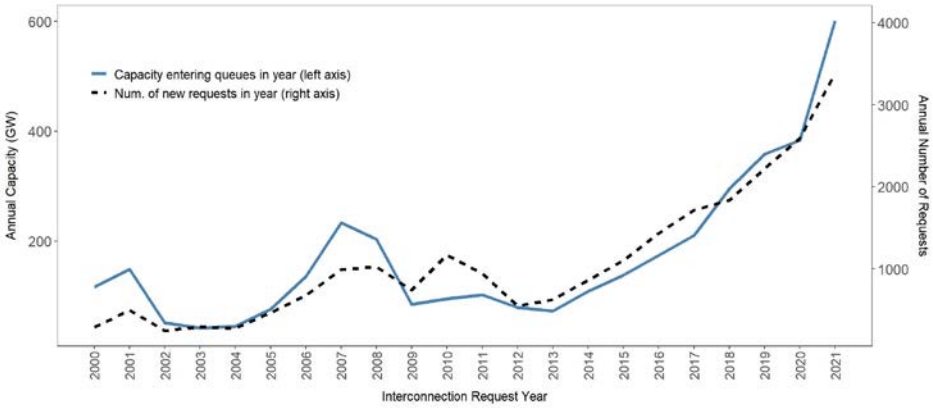
U.S. Transmission Interconnection Queues

- Substantial solar and storage capacity have been proposed in most regions of the United States.
- Annual interconnection requests have increased dramatically—in terms of both number and capacity—since 2013; over 600 GW was added in 2021 alone.
- Less than 23% of all projects proposed from 2000 to 2016 have reached commercial operations.
  - Wind (20%) and solar (16%) have lower completion rates from 2000 to 2016 than other electric generation technologies.

Proposed Interconnections by Technology

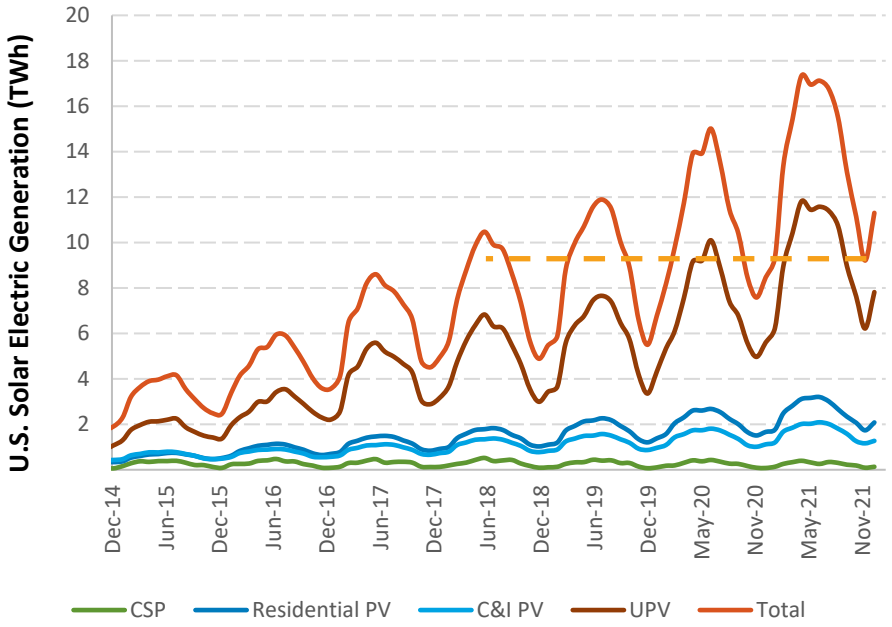


Interconnection Requests by Year



Source: LBNL, Queued Up: Characteristics of Power Plants Seeking Transmission Interconnection as of the End of 2021.

Monthly U.S. Solar Generation, 2014–2021



- Total peak monthly U.S. solar generation increased by a factor of 5.7 from 2014 to 2021.
  - U.S. electric generation in December 2021 (during the low seasonal period of electric generation) was slightly below the peak solar production in 2018.
  - In May 2021, solar produced 5.4% of all U.S. electricity production.
- Utility-scale solar electricity production (including PV and CSP technologies) dropped by 53% from its summer peak (May 2021) to its winter low (December 2021), and DPV systems dropped 47%.
  - The drop in production would likely be greater without continued builds of solar installations throughout the year.

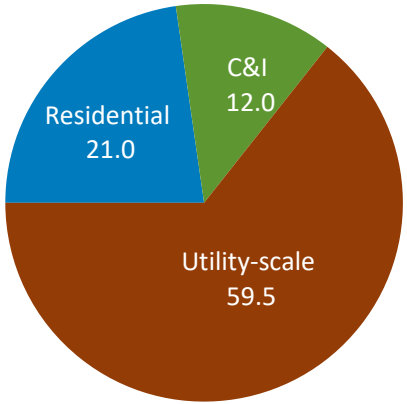
Note: EIA monthly data for 2021 are not final. Additionally, smaller utilities report information to EIA on a yearly basis, and therefore, a certain amount of solar data have not yet been reported. "Net Generation" includes DPV generation.
Sources: EIA, "Monthly Energy Review," (April 2022).

U.S. Installation Breakdown Annual: EIA (GWac)

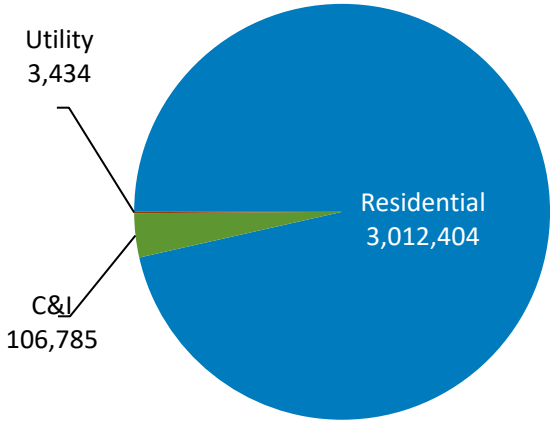
- At the end of 2021, there were 92.5 GWac of cumulative PV installations.
- EIA reports that at the end of 2021, 64% of U.S. installed PV capacity was from utility-scale PV systems.

- Despite representing only 23% of installed U.S. PV capacity at the end of 2021, 96% of PV systems—over 3 million systems—were residential applications.

Cumulative U.S. PV Installations as of December 2021 (92.5 GWac)

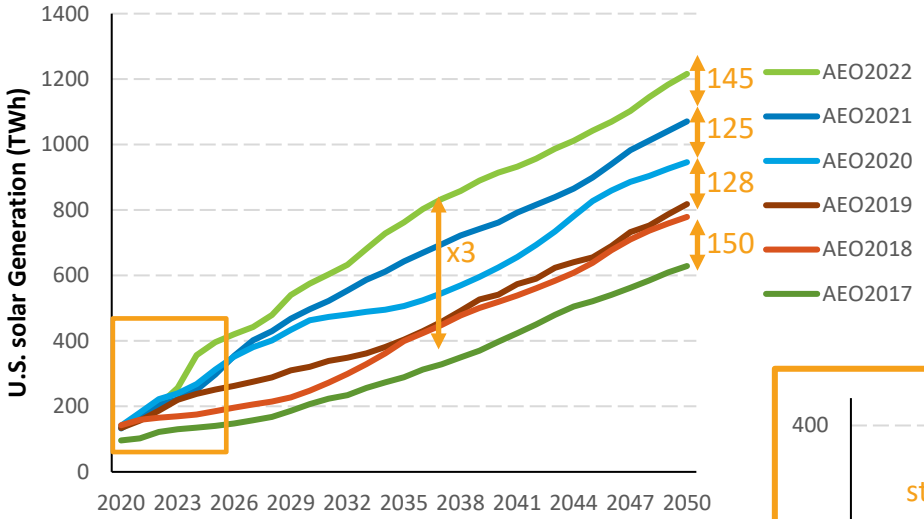


Cumulative U.S. PV Installations as of December 2021 (number)

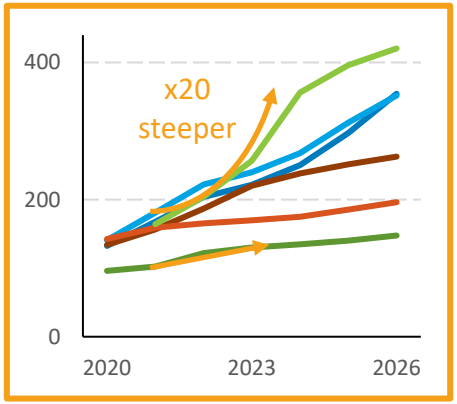


Note: EIA reports values in Wac which is standard for utilities. The solar industry has traditionally reported in Wdc. See the next slide for values reported in Wdc.
Sources: EIA, "Electric Power Monthly," forms EIA-023, EIA-826, EIA-860, and EIA-861 (April 2022, February 2021, February 2019).

EIA Projections Over Time



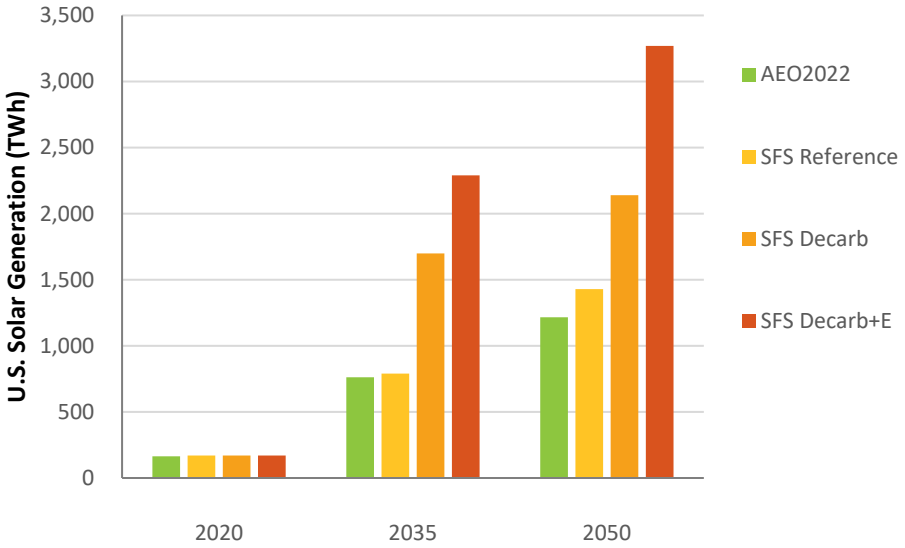
- Between EIA's Annual Energy Outlook (AEO) 2017 and EIA's AEO2022, PV projections have increased significantly.
  - AEO2022 projects 145 TWh more deployment by 2050 than AEO2021, continuing a trend a of the past few years (except for AEO2018/2019 which gave similar 2050 projections).
  - Between 2024 and 2034, projections of solar generation nearly tripled between AEO2017 and AEO2022.



  - AEO2022 projects a markedly steeper ramp (over 20x faster than that projected in AEO2017) in solar generation from 2023 to 2024.

Sources: EIA, 2022 Annual Energy Outlook, reference case.

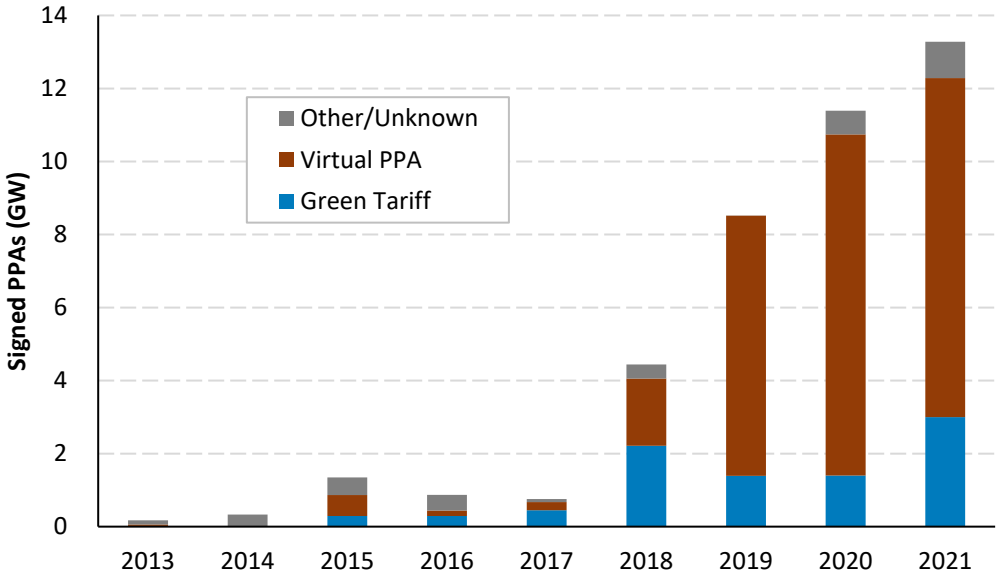
AEO Compared to Solar Futures Study



- Despite these increases, compared to the Solar Futures Study (SFS) scenarios, AEO2022 still projects increases will fall short of the scale needed to meet the Biden Administration climate goals.
  - By 2035, AEO2022 projects nearly the same solar generation as the SFS Reference scenario and less than half the solar generation modelled in the Decarb scenario.
  - By 2050 , AEO2022 projects 200 TWh less solar generation than the SFS Reference scenario and 56% of the Decarb scenario.

Sources: EIA, 2022 Annual Energy Outlook, reference case, Solar Futures Study scenarios.

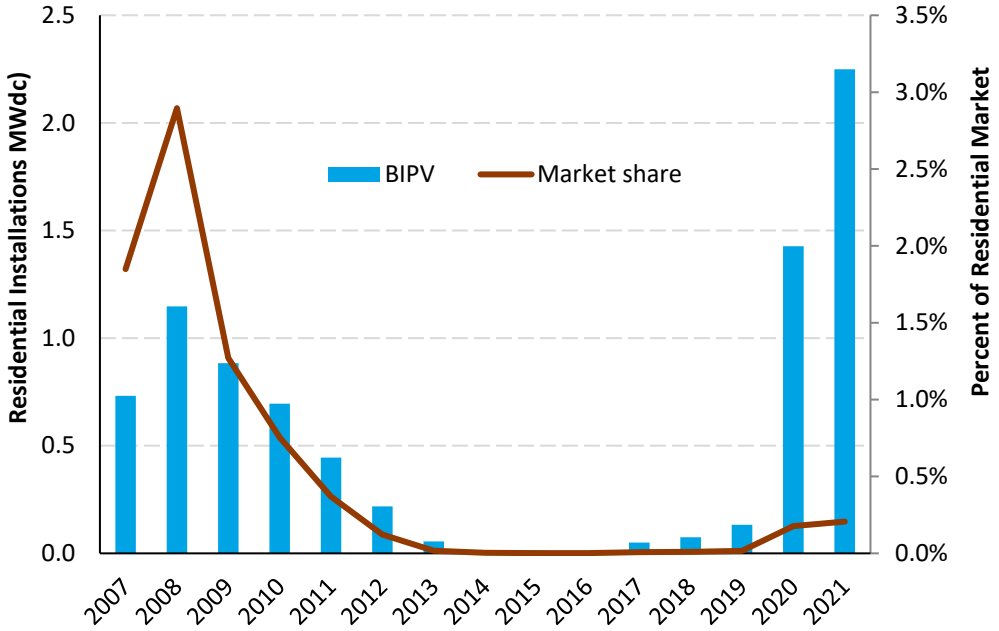
U.S. Off-Site Corporate Solar PPAs



- Led by the tech industry and Fortune 500 companies, U.S. corporate solar contracts were up 17% in 2021, y/y, and the contracted capacity was 15 times larger than 5 years ago.
  - The United States represented approximately 73% of the global offsite corporate solar market in 2021, followed by Spain (8%) and Canada (4%).
  - 70% of the 2021 U.S. solar contracts were in the form of virtual PPAs, with the remainder coming mostly from green tariffs.
  - In addition to the 13.3 GW of U.S. solar PPAs, companies signed 3.6 GW of U.S. wind projects.
- Through 2021, the leading five U.S. offsite corporate solar offtakers were Amazon, Meta, Microsoft, Google, and Verizon, with a collective 20 GW of PPAs.
  - In 2021 alone, Amazon signed 3.2 GW, Microsoft signed 2.5 GW, and Meta signed 2.0 GW of offsite U.S. solar PPAs.

Sources: BloombergNEF, "Corporate PPA Deal Tracker," as of March 9, 2022.

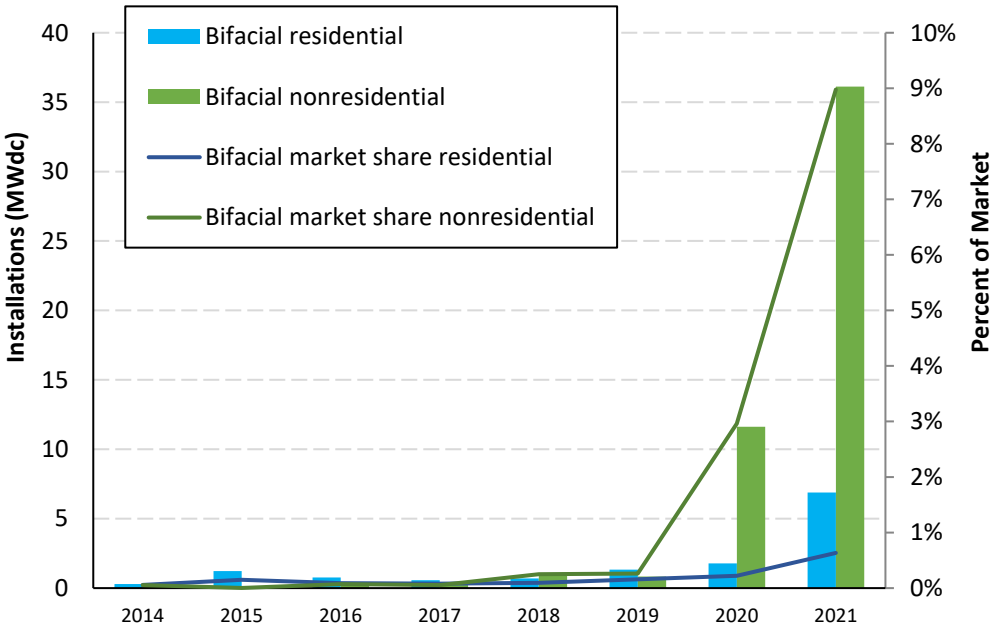
Residential Uptick in Building-Integrated Photovoltaics in California



- In 2021, 2.2 MW of residential building-integrated photovoltaics (BIPV) was installed in the California IOU territories—its highest amount in over a decade of tracking.
  - The BIPV growth in 2021 continued the trend of rapid growth observed in 2020.
  - Tesla installed 98% of this BIPV capacity in 2021.
    - Tesla may face more competition in the near future. One of the largest roofing manufacturers in North America, GAF – which supplied roofs to roughly ¼ of North American homes – launched a solar shingle product of their own in late 2021.
- Despite this growth, BIPV made up only 0.2% of total residential PV installed in the California IOU territories in 2020 and 2021.

Note: BIPV, as defined by the California Energy Commission's PV Module List, includes modules that are not rack mounted.
Sources: CA NEM database (12/31/21); Fast Company (05/03/22); Forbes (04/19/21).

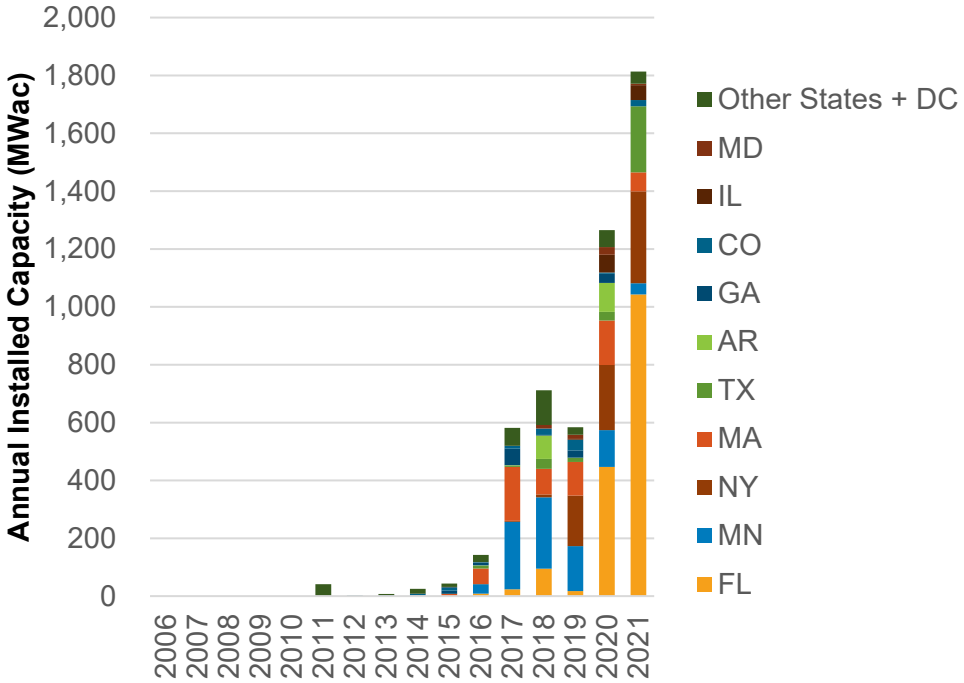
Bifacial Increase in California Distributed PV Installations



- In 2021, 43 MW of bifacial modules was installed in the California IOU territories—three times more than in 2020.
  - 7 MW (0.6%) of residential capacity was bifacial.
  - 36 MW (9%) of nonresidential capacity was bifacial.
- Flat-roof nonresidential PV installations provide bifacial energy gain, but typical sloped residential rooftop installations do not provide bifacial gain.
  - Bifacial modules were associated with larger nonresidential systems; for example, 18% of nonresidential capacity was bifacial in 2021 for systems of 500+ kW.
  - Size trends for bifacial versus monofacial modules were less pronounced for residential systems.
  - Installers may use bifacial modules to avoid tariff-related module costs: bifacial modules were exempt from Section 201 tariffs (enacted February 2018) from June 2019 to November 2020, and from November 2021 to the present.
- California's distributed generation data do not include utility-scale PV projects, which are the primary application for bifacial modules.

Note: Bifacial modules are defined as having the term "bifacial" in the description field in the California Energy Commission's PV Module List.
Source: CA NEM database (12/31/21); Solar Power World (11/16/21); DOE, Solar Futures Study

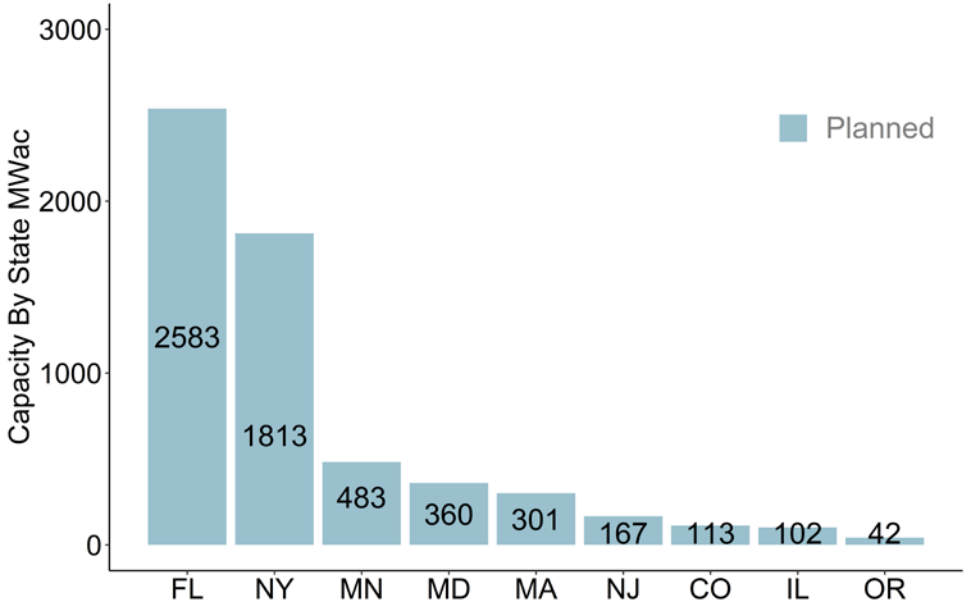
Annual Community Solar Installations, 2006–2021



- Cumulative community solar capacity topped 5 GWac as of 2021 and spanned ~2,000 projects in 40 states and Washington, D.C.
- As of 2021, annual U.S. installations were 43% (1.8 GWac) above 2020 installations thanks largely to over 1 GWac of installations in Florida.
- The second-largest state in 2021 was New York with over 300 MWac of projects. It installed 414 GWac of community solar projects from 2016 to 2020.

Note: The National Renewable Energy Laboratory's (NREL) definition of Community Solar: "… a solar installation with multiple offtakers or owners, referred to as "subscribers." The subscribers enter a contractual relationship with the owner or operator of the installation (or an intermediary) to receive some or all of the financial returns from a predefined share of the installation's output." Data Source: NREL Sharing the Sun data set (2022) and publication (2021)

Planned Community Solar Installations, 2021

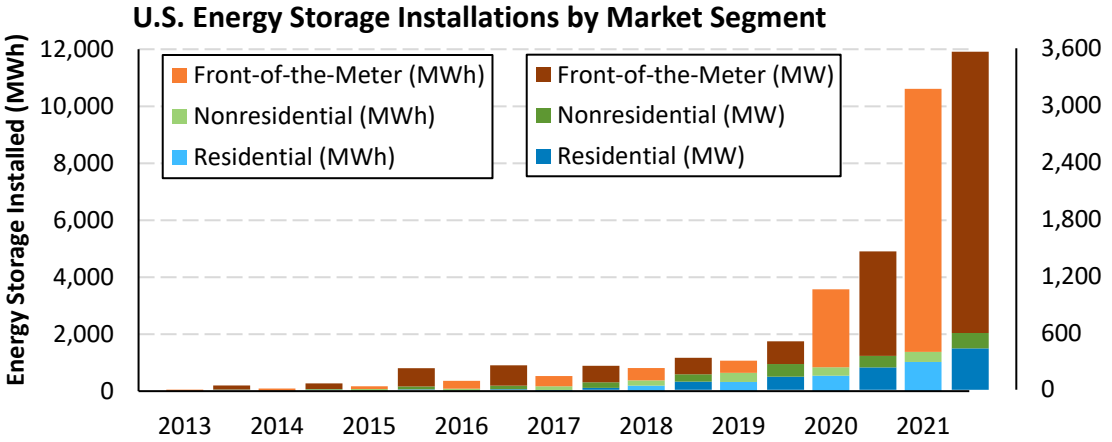


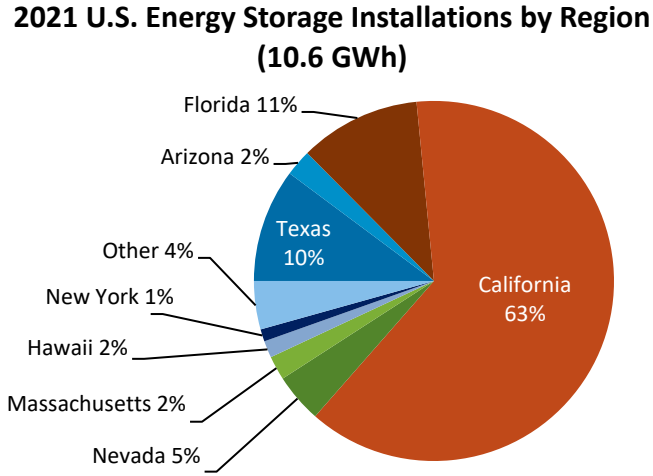
- Nearly 5.9 GWac of projects were in the NREL project queue as of 2021, indicating the market is continuing to grow; most of the planned capacity was in Florida, New York, Minnesota, and Maryland.
  - Projects in the NREL queue are either under construction or were awarded and accepted project capacity from administrators.
  - If all these projects come online, the cumulative community solar capacity would double.

FL: Duke Energy Program and FPL Program, NY: New York Solar Electric Programs Reported by NYSERDA ; MN: Xcel Compliance Filling Monthly Update, DOCKET No. 13-867 Xcel projects only; MD: Community solar pilot program MA: Solar Massachusetts Renewable Target (SMART) Application Update; NJ: Community Solar Program; CO: Solar*Rewards RES Compliance Report Xcel projects only; IL: Adjustable Block Program Community Solar; OR: Community solar program in

U.S. Energy Storage Installations by Market Segment

- The United States installed approximately 10.6 GWh (3.6 GWac) of energy storage onto the electric grid in 2021, +197% (+144%) y/y, as a result of record levels of residential and front-of-the-meter deployment.
  - Q4 2021 is the first quarter during which >1 GW_{ac} of front-of-the-meter storage was installed.
  - Front-of-the-meter, nonresidential, and residential were up 169%, 32%, and 86% in 2021 y/y, respectively.
- California continues to dominate front-of-the meter and residential installations. And Puerto Rico, Texas, Florida, and Nevada had significant 2021 installations.
  - Florida notably jumped from 1% to 10% of installations in Q4 2021 (mainly as a result of one 409 MW_{ac} project).
- New York overtook Massachusetts in the nonresidential sector as a result of community-scale storage.
- Despite the record levels of storage deployment, over 2 GW of grid-scale capacity originally slated to come online in Q4 2021 was delayed to 2022 and 2023 due to supply chain issues.





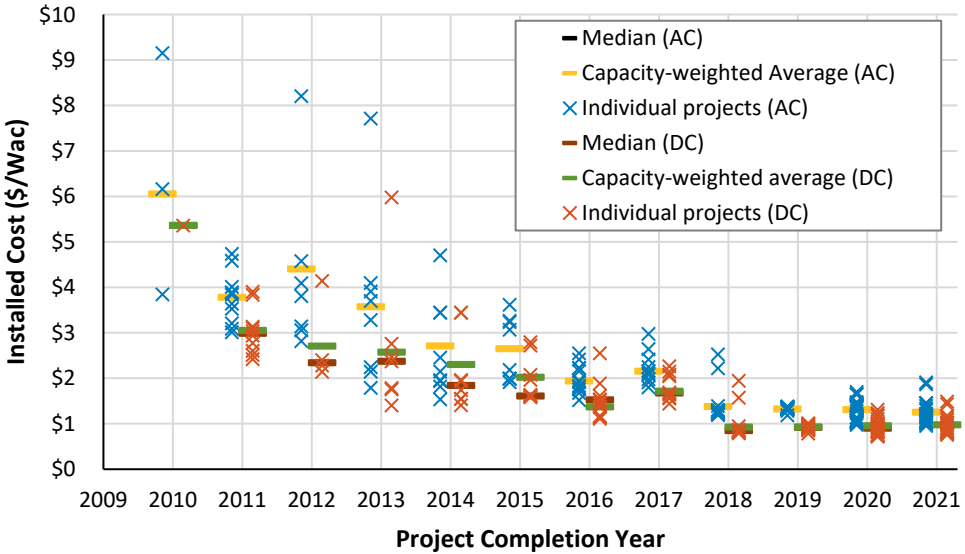
Source: Wood Mackenzie Power & Renewables and Energy Storage Association, U.S. Energy Storage Monitor: Q4 2021. Ohio nonresidential deployment MW data were corrected for a suspected data entry error.

Agenda

1. Global Solar Deployment
2. U.S. PV Deployment
3. **PV System Pricing**
4. Global Manufacturing
5. Component Pricing
6. Market Activity
7. U.S. PV Imports

- **In a select data set of utility-scale PV systems owned by 25 regulated utilities for 166 projects totaling 7.3 GWac, the median system price in 2021 was $1.20/Wac ($0.97/Wdc)—down 11% y/y in Wac but up 8% in Wdc.**
- **The median reported price by EnergySage for residential PV systems decreased 2.5% between H2 2020 and H2 2021 but increased between H1 and H2 2021—the first reported increase on record.**
  - EnergySage reports an increase in storage costs—unlike solar pricing—over time. Many of the increases in state price medians are correlated to a decrease in median system size.

Utility-Owned PV Pricing (>5 MW)

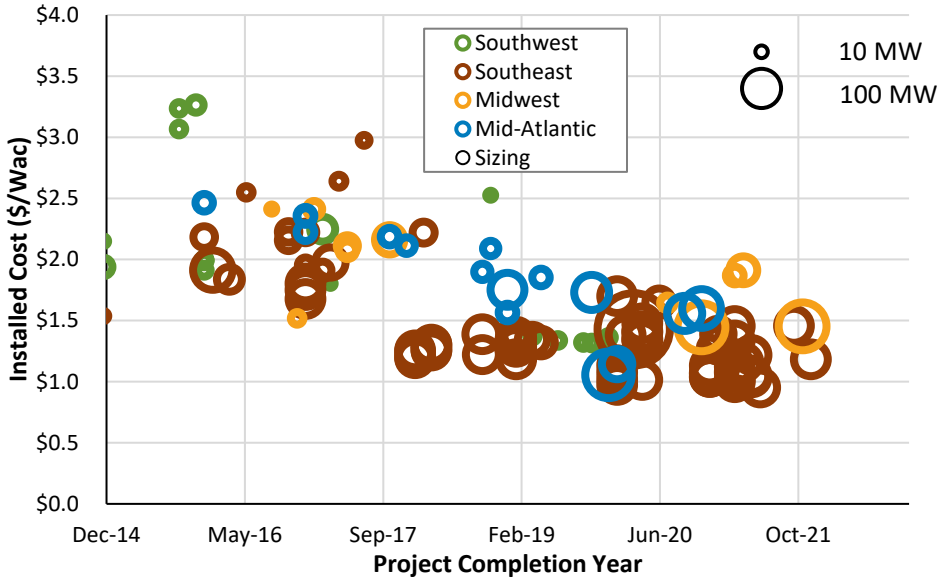


In a select data set of utility-scale PV systems owned by 25 regulated utilities for 166 projects totaling 7.3 GWac, the median system price in 2021 was $1.20/Wac ($0.97/Wdc)—down 11% y/y in Wac but up 8% in Wdc.

- The lowest and highest reported prices in 2021 were $0.95/Wac and $1.91/Wac ($0.76/Wdc and $1.49/Wdc).
- From 2010 through 2021, system prices fell 13% per year on average per Wac and 15% per year on average per Wdc.

Sources: FERC Form 1 filings from the from the following utilities: Alabama Power, Allete, Arizona Public Service, Avangrid, DTE, Duke Energy, El Paso Electric, Florida Power and Light, Georgia Power, Indiana Michigan Power, Kentucky Utilities, Nevada Power, Pacific Gas and Electric, Public Service of New Mexico, Southern California Edison, Tampa Electric, Tucson Electric, United Illuminating, UNS Electric, and Virginia Electric.

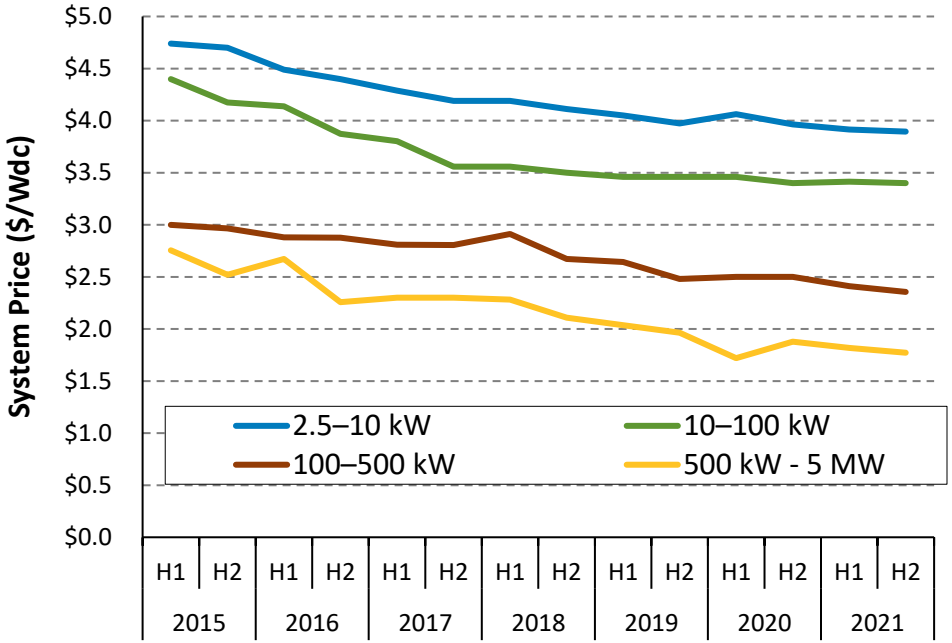
Utility-Owned PV Pricing (>5 MW)



- In a select data set of utility-scale PV systems (166 projects totaling 7.3 GWac) owned by 25 regulated utilities, the average system size has trended upward as system pricing has trended downward over the past 7 years.
  - The average system size in this data set was 15 MWac in 2015 and 73 MWac in 2021 (94 MWdc).
- System prices have been relatively in-line across several different regions but generally lower in the Southeast.
  - Utility-owned projects still represent a minority of all PV systems installed in the United States, and prices may differ from IPP-owned projects.

Sources: FERC Form 1 filings from the from the following utilities: Alabama Power, Allete, Arizona Public Service, Avangrid, DTE, Duke Energy, El Paso Electric, Florida Power and Light, Georgia Power, Indiana Michigan Power, Kentucky Utilities, Nevada Power, Pacific Gas and Electric, Public Service of New Mexico, Southern California Edison, Tampa Electric, Tucson Electric, United Illuminating, UNS Electric, and Virginia Electric.

System Pricing from Select States



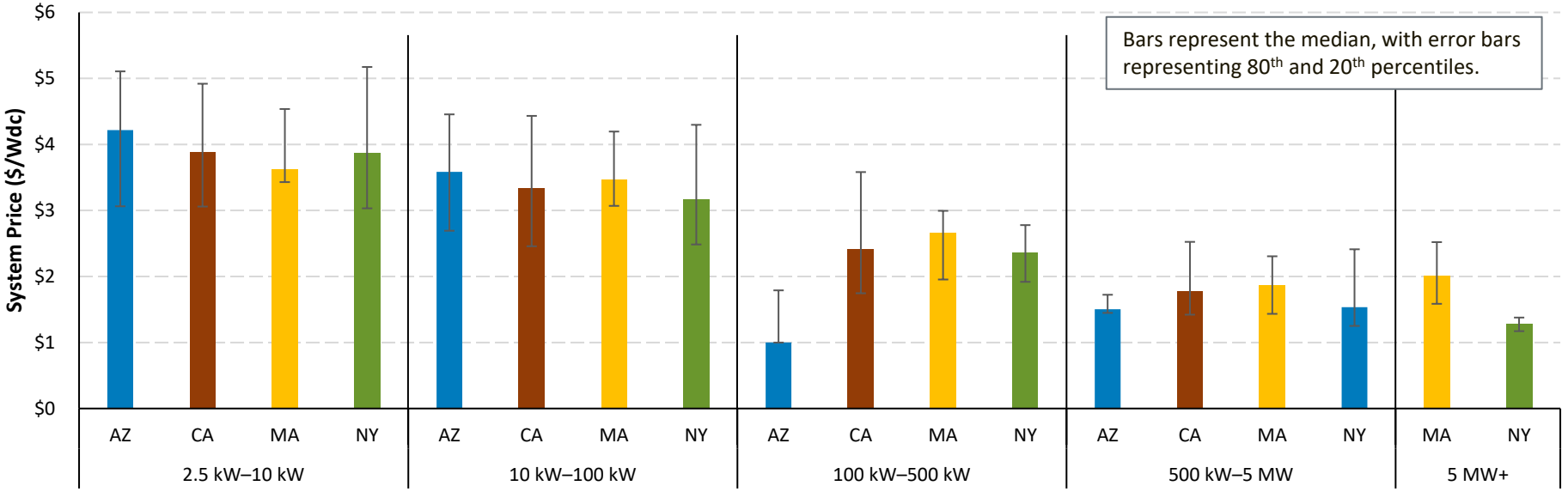
- From H2 2020 to H2 2021, the median reported PV system price in Arizona, California, Connecticut, Massachusetts, and New York:
  - Fell 2% to $3.90/W for systems from 2.5 kW to 10 kW
  - Was flat at $3.40/W for systems from 10 kW to 100 kW
  - Fell 6% to $2.36/W for systems from 100 kW to 500 kW
  - Fell 6% to $1.77/W for systems from 500 kW to 5 MW.
- Adding system data available after the previous Solar Industry Update was published (in January 2022) resulted in a 6% lower H2 2021 price for systems from 500 kW to 5 MW, compared with the H2 2021 price reported in January.

2021 MW: Arizona (210), California (1,040), Connecticut (36), Massachusetts (383), New York (546)
Note: System prices above $10/W and below $0.75/W were removed from the data set. There were not enough reported prices for systems above 5 MW in this data set to show a trend over time.
Sources: Arizona (date of data varies, as late as 2/28/22); California NEM database (12/31/21); Connecticut (1/13/22); Massachusetts SREC (09/01/21) and SMART (1/28/22) programs; NYSERDA (2/22/22).

System Pricing from Select States, H2 2021

- In addition to price differences based on system size, there is variation between states and within individual markets.

- The median price of a 10–100 kW system in New York was 12% lower than the median in Arizona.
- The low Arizona price for 100–500 kW systems is mostly due to 26 Salt River Project systems in H2 2021.
- Sample sizes are small for larger systems: 39 total systems of 5 MW+, 123 systems of 500 kW–5 MW, and 351 systems of 100–500 kW, compared with about 84,000 systems of less than 100 kW.



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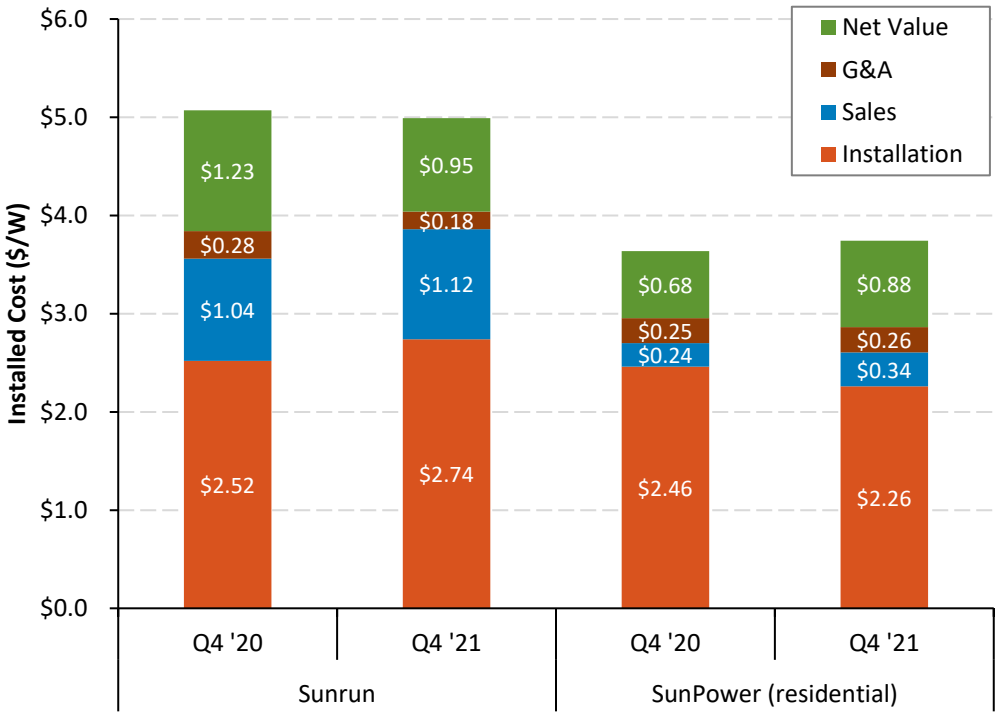
Sunrun and SunPower Cost and Value, Q4 2021

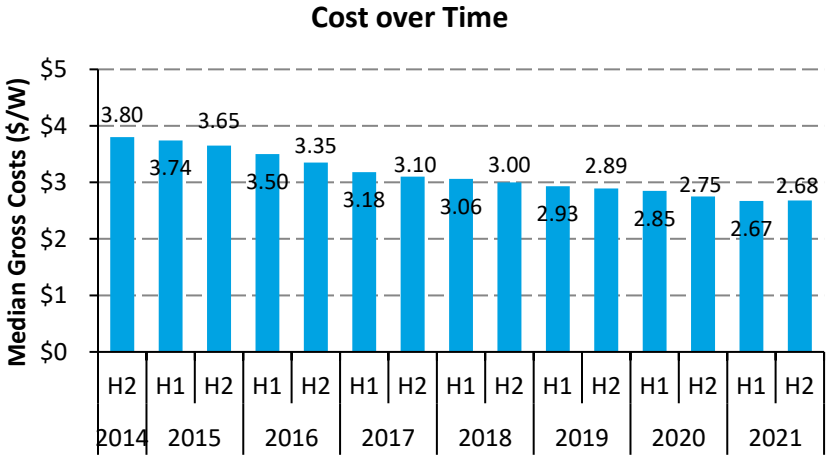


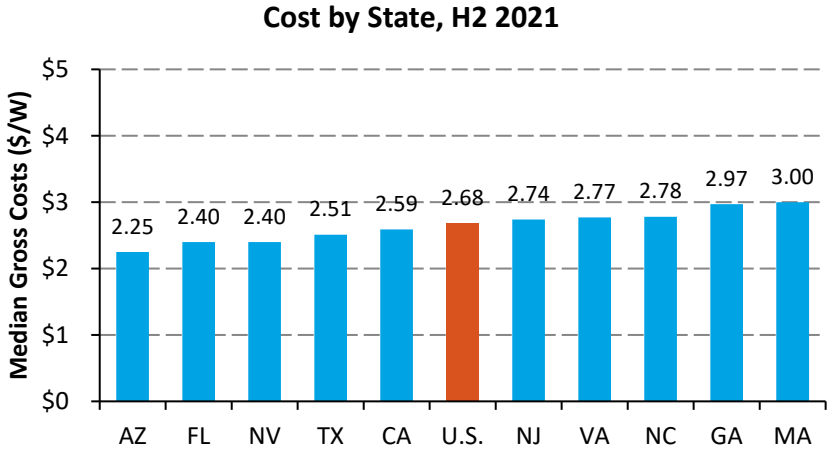
- Residential installers reported reduced productivity and higher-than-expected costs in Q4 2021 related to the COVID-19 omicron surge, adverse weather, and continuing supply chain and labor challenges.
  - Tesla cited import delays of solar components as the reason its Q1 2022 deployment shrank 48%.
- Costs include PV systems paired with batteries, which are increasing in popularity.
  - Sunrun battery installations increased more than 100% y/y in 2021, totaling 32,000 PV+storage systems (~5% of total customers).
  - Sunnova reported a battery attachment rate of 22% in Q4 2021, and an increase in battery penetration rate from 9% at end of 2020 to 11% at end of 2021.
  - Tesla announced in April 2021 it would only sell solar paired with storage.

Sources: Corporate filings; UtilityDive (04/27/21).

Residential System Price Reported by EnergySage

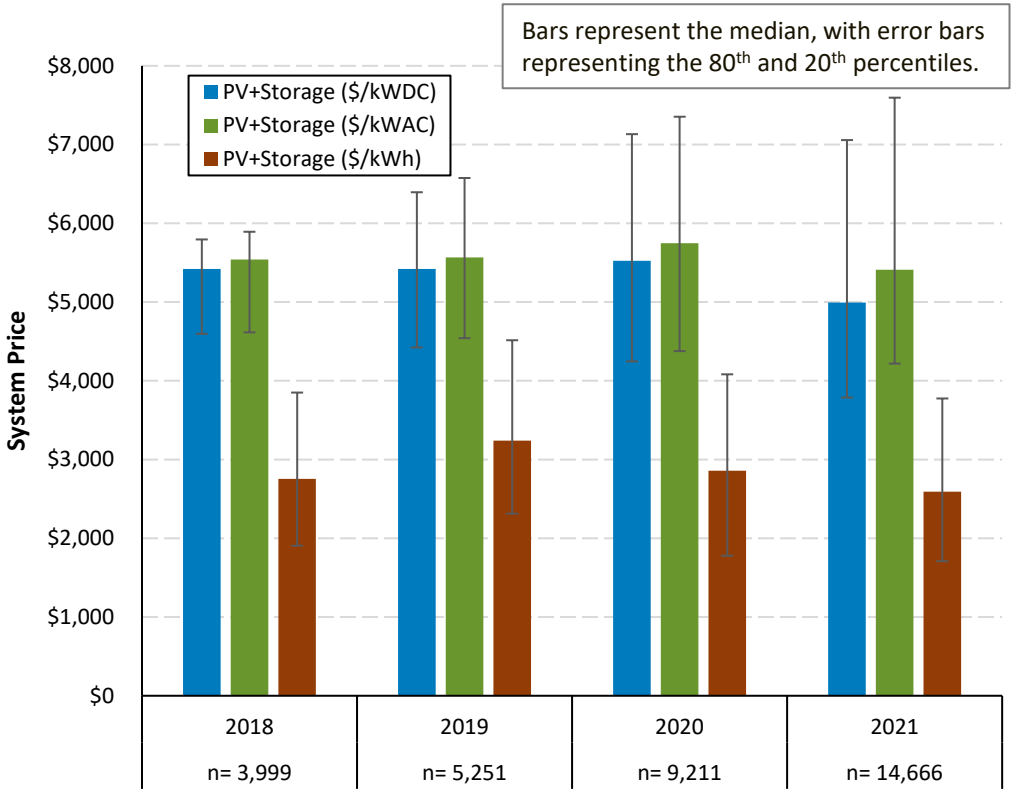
- The median reported price by EnergySage for residential PV systems decreased 2.5% between H2 2020 and H2 2021 but increased between H1 and H2 2021—the first reported increase on record.
- Residential system price varied by state. In H2 2021, the median price of a residential system in Massachusetts was 33% higher than the median price of a residential system in Arizona.
  - Part of the price disparity between states is due to differences in average system size, though other factors, such as cost of living (e.g., Massachusetts), also play a role.





Note: price based on winning quoted price.
Source: EnergySage, "Solar Market place Intel Report H1 2021 – H2 2021."

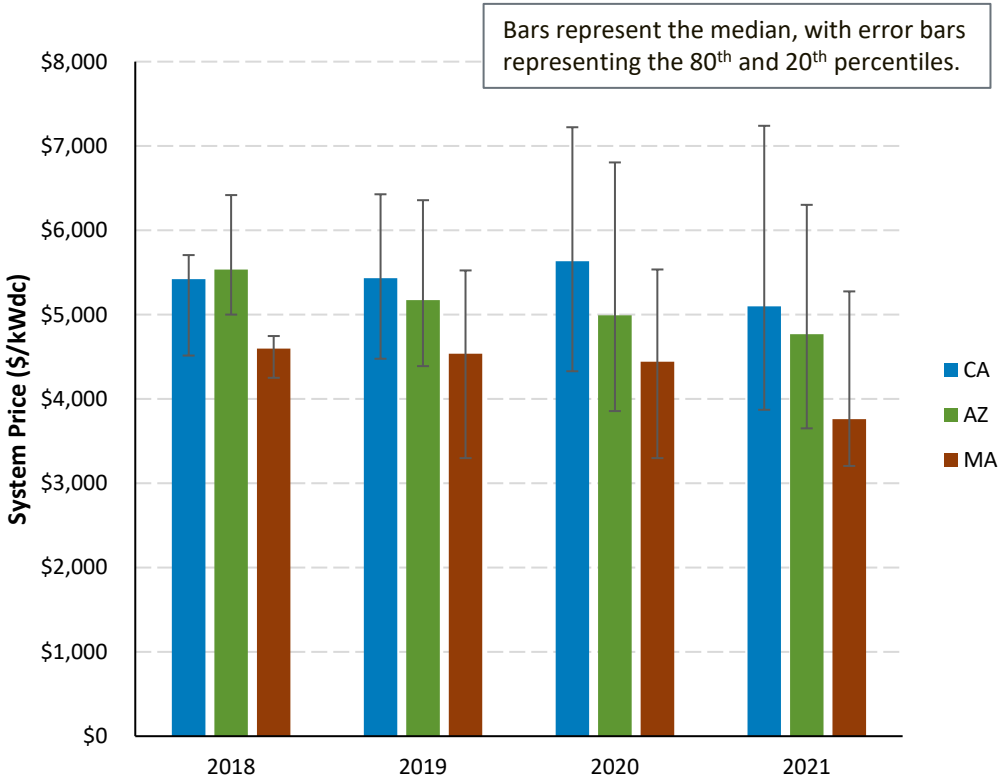
Residential U.S. PV+Storage Pricing



- In 2021, residential PV+storage systems in Arizona, California, and Massachusetts had a median system price of $2,600/kWh, or $5,400/kWac ($5,000/kWdc)—a reduction of 6%–10% compared to full 2020 median values.
  - Most of these systems offer 2–3 hours of storage.
  - Units represent total system price divided by the capacity of the battery (kWh) or the capacity of the PV system (kW).

2021 residential PV+storage MW: Arizona (11), California (132), Massachusetts (8)
Most recent sources: Arizona Goes Solar (2/28/22); California NEM database (12/31/21); Massachusetts SMART program (1/28/22)

Residential U.S. PV+Storage Pricing

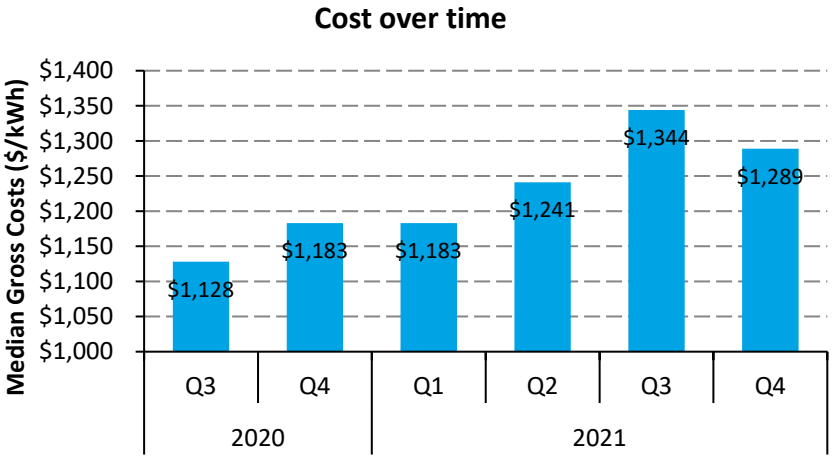


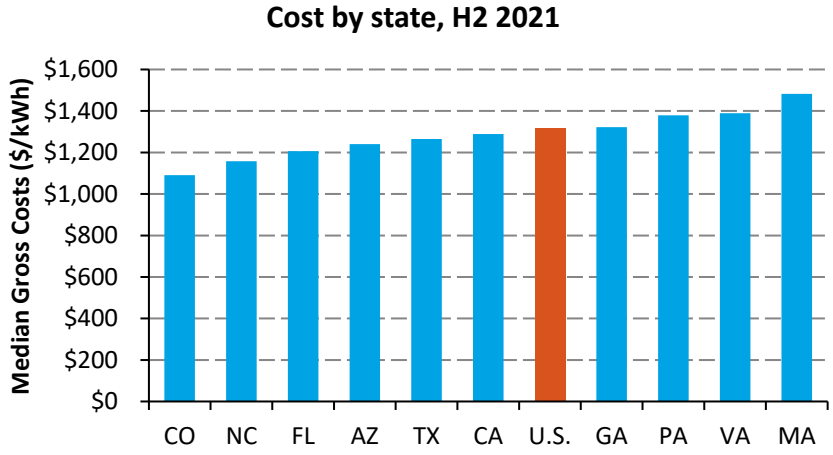
- In 2021, residential PV+storage system prices in Arizona, California, and Massachusetts varied between states and internally.
  - Prices may vary due to differences in storage power and capacity, permitting and interconnection differences, local competitive factors, and installer experience.

2021 residential PV+storage MW: Arizona (11), California (132), Massachusetts (8)
Most recent sources: Arizona Goes Solar (2/28/22); California NEM database (12/31/21); Massachusetts SMART program (1/28/22)

Residential Storage Price Reported by EnergySage

- EnergySage reports an increase in storage costs—unlike solar costs—over time.
  - Many of the increases in state price medians are correlated to a decrease in median system size.
- Residential storage system price varied by state. In H2 2021, the median price of a residential storage system in Massachusetts was 36% higher than the median price of a residential storage system in Colorado.





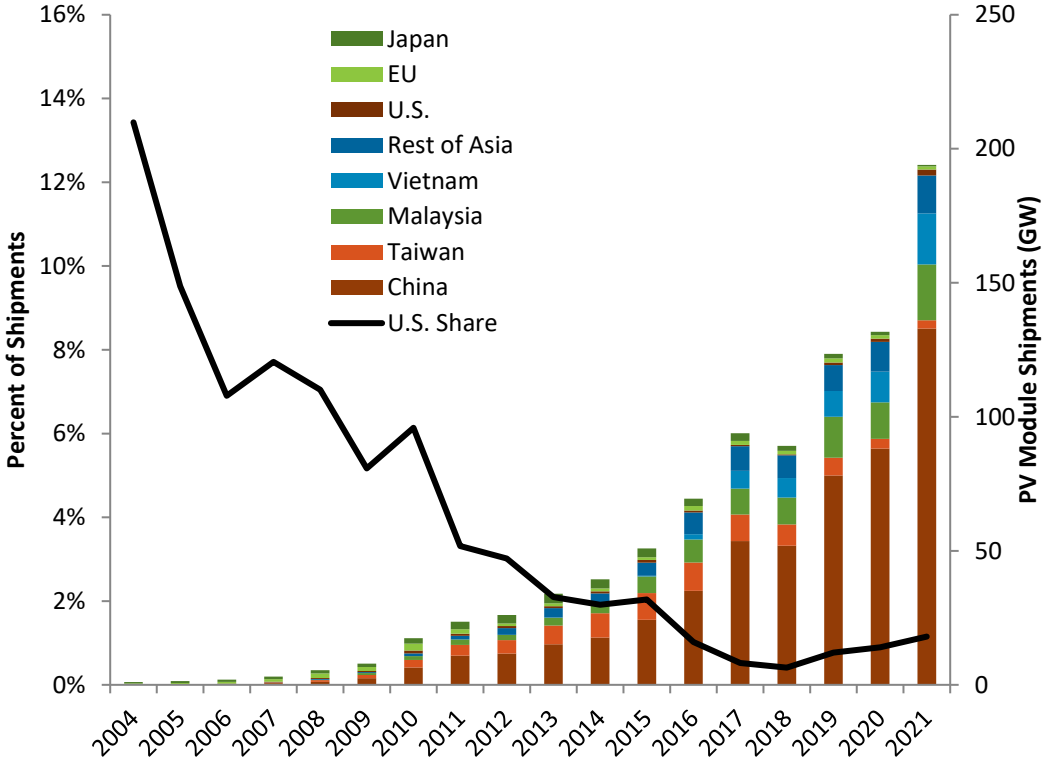
Note: price based on winning quoted price.
Source: EnergySage, "Solar Market place Intel Report H1 2021 – H2 2021."

Agenda

1. Global Solar Deployment
2. U.S. PV Deployment
3. PV System Pricing
4. **Global Manufacturing**
5. Component Pricing
6. Market Activity
7. U.S. PV Imports

- **In 2021, global PV shipments were approximately 194 GW—an increase of 47% from 2020.**
- **In 2021, 95% of PV shipments were mono c-Si technology, compared to 35% in 2015 (when multi c-Si peaked at 58%).**
  - Mono P PERC was the dominant cell type in 2021, though n-type shipments grew to 40 GW, from 6 GW in 2019, to 20% of the market.
- **In 2021, the average module efficiency of modules installed in the United States was approximately 20.0% for mono c-Si, 17.6% for multi c-Si, and 18.2% for CdTe.**
- **In 2021, the United States produced a record 4.8 GW of PV modules, up 11% y/y, mostly as a result of a 25% increase in production by First Solar.**
  - In 2021, revenue from PV deployment was 17x revenue from PV manufacturing.

Global Annual PV Shipments by Region*

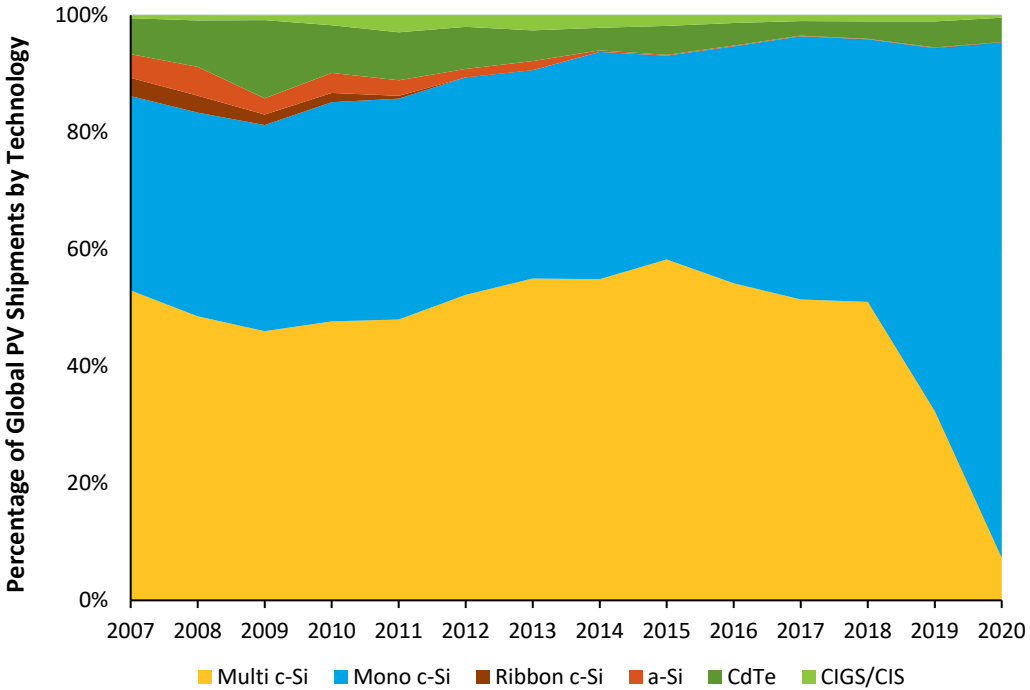


- In 2021, global PV shipments were approximately 194 GW—an increase of 47% from 2020.
- From 2004 to 2021:
  - The U.S.-manufactured percentage of global PV shipments declined from around 13% to 1.2% (though it achieved its highest level since 2015).
  - The chinese-manufactured share of global PV shipments grew from 1% to 69%.
  - Together the Malaysian-, Vietnamese-, and South Korean-manufactured percentage of global PV shipments went from 0% to 24% (with Vietnamese growth coming on rapidly during the last 5 years).

*** Note:** excludes inventory sales and outsourcing

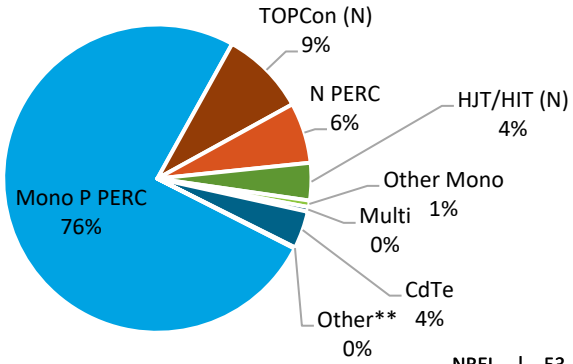
Source: Paula Mints. "Photovoltaic Manufacturer Capacity, Shipments, Price & Revenues 2021/2022." SPV Market Research. Report SPV-Supply10. April 2022.

Global Annual PV Shipments by Technology*



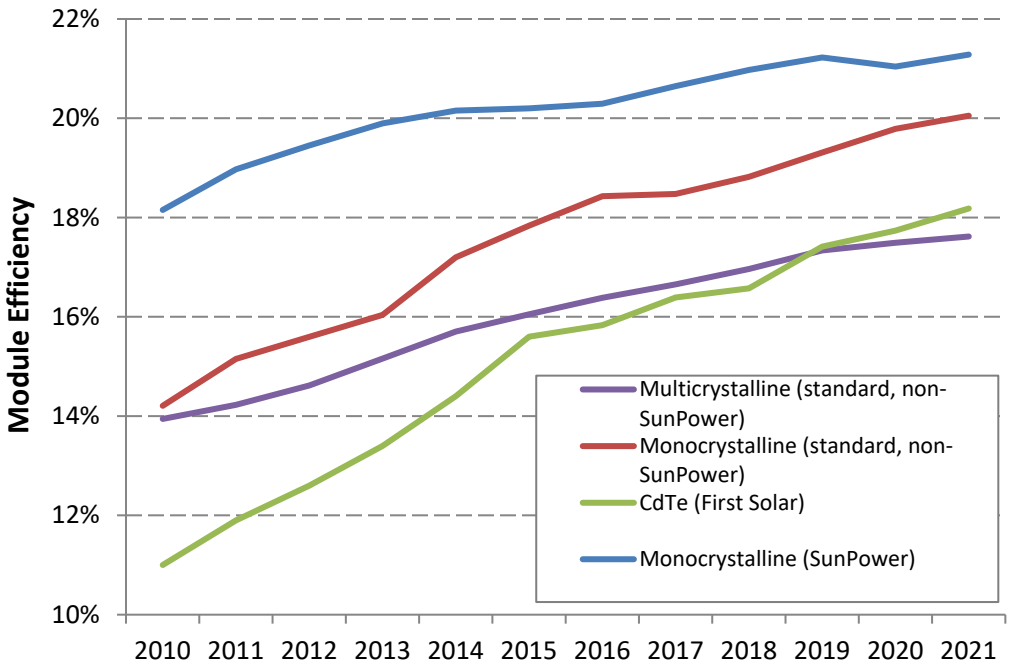
- In 2021, 95% of PV shipments were mono c-Si technology, compared to 35% in 2015 (when multi c-Si peaked at 58%).
- Mono P PERC was the dominant cell type in 2021, though n-type shipments grew to 40 GW, from 6 GW in 2019, to 20% of the market.
  - China shipped ~80% of HJT and TopCon N-type cells but only ~40% of N-type PERC and no CdTe or IBC cells.

2021 Market Share by Cell Type



***Notes:** excludes inventory sales and outsourcing
** includes a-Si and CIS/CIGS
Source: Paula Mints. "Photovoltaic Manufacturer Capacity, Shipments, Price & Revenues 2021/2022." SPV Market Research. Report SPV-Supply10. April 2022.

PV Efficiency Improvements



- From 2010 to 2021, the weighted average efficiency of modules installed in the United States increased significantly:
  - 14.2%–20.0% for standard mono c-Si
  - 13.9%–17.6% for standard multi c-Si
  - 11.0%–18.2% for CdTe.
- Data available for c-Si modules from the first few months of 2022 show average efficiency continuing to increase.
- Standard mono c-Si modules have closed the gap with SunPower mono c-Si modules, which have long been among the highest-efficiency premium products.
  - A 3.9 percentage point gap in 2010 decreased to 1.2 points in 2021.

Sources: CdTe: First Solar Investor Relations, average module efficiency produced. c-Si: California Interconnection Dataset (2/28/22); standard modules include non-SunPower modules with 60, 72, or 144 cells.

Global Leading PV Manufacturers by Shipments

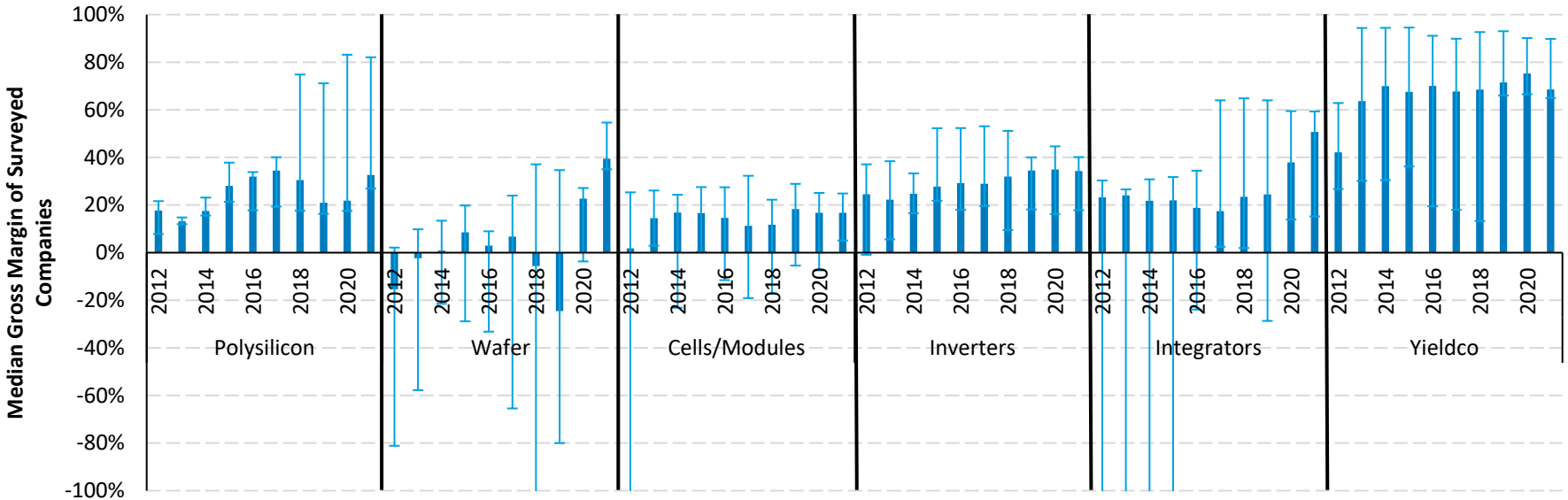
Ranking	2016	MWp	2020	MWp	2021	MWp
1	Trina	4,998	LONGI	14,683	Aiko	31,274
2	JA Solar	4,920	Tongwei	12,100	Tongwei	27,344
3	Hanwha Q-Cells	4,046	JA Solar	10,751	LONGi	19,637
4	Jinko Solar	3,890	Aiko Solar	10,521	Jinko Solar	16,849
5	Motech Solar	2,925	Trina Solar	9,001	Zhongli Talesun	10,731
6	First Solar	2,650	Jinko Solar	8,655	JA Solar	10,658
7	LONGi	2,650	Canadian Solar	8,337	Canadian Solar	8,675
8	Canadian Solar	2,440	Zhongli	7,435	Runergy	8,017
9	Yingli Solar	2,360	Suntech	6,313	Hanwha Q-Cells	7,614
10	Suntech	2,228	First Solar	5,500	First Solar	7,611
Total Above		**33,107**		**93,294**		**148,410**
Total Shipped		**69,460**		**131,709**		**193,966**

- From 2016 to 2021, shipments from the top 10 PV manufacturers grew from 33 GW to 148 GW, with some companies shipping more than 20 GW annually.
- New companies quickly moved to top spots, in part through the rapid growth of mono c-Si production.
- The list of leading companies remained relatively stable between 2020 and 2021, as the top ten manufacturers grew their market share from 71% to 77%—up from 48% in 2016.

***Note:** Excludes inventory sales and outsourcing.
Source: Paula Mints. "Photovoltaic Manufacturer Capacity, Shipments, Price & Revenues 2021/2022." SPV Market Research. Report SPV-Supply10. April 2022.

Gross Margin Across Supply Chain

- All sectors saw increases in gross margin from 2020 to 2021 except yieldcos, which had a slight drop, while cell/modules and inverters held steady.
- Of the sectors that improved in 2021, polysilicon, wafers, and integrators saw the most significant growth in gross margin.

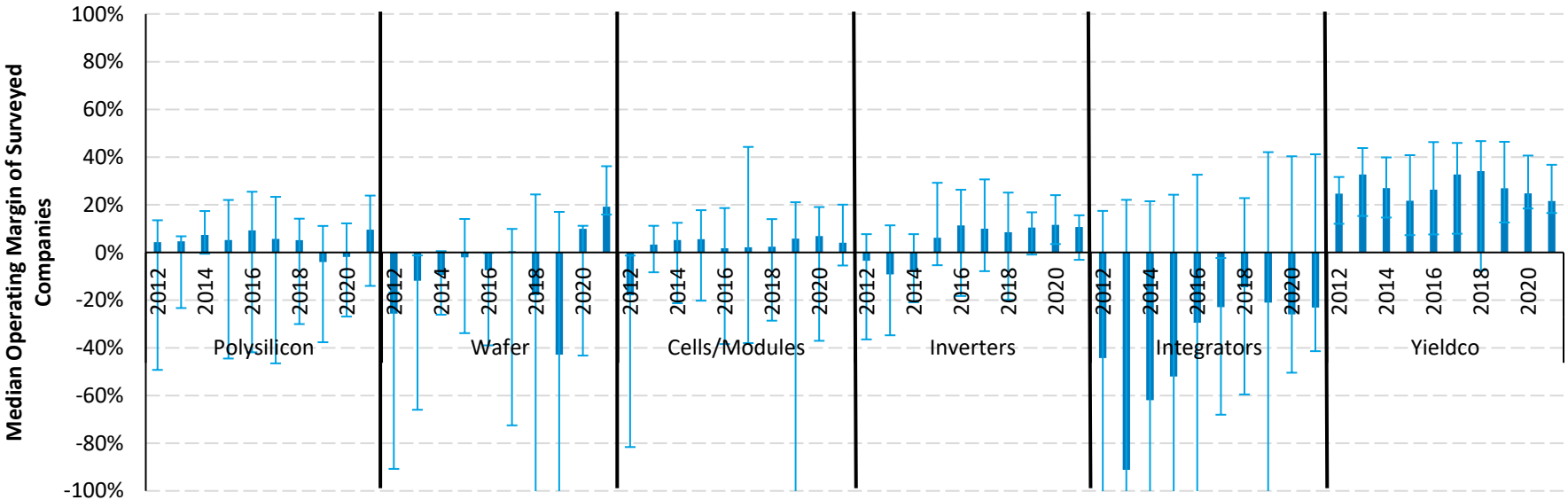


Sources: Company figures from public filings and finance.yahoo.com. Error bars represent high and low values of surveyed companies. Companies surveyed are Polysilicon – GCL Poly, REC Silicon, Wacker Chemie, Ferroglobe; Wafers - ReneSola, Wafer Works Corp, Danen Technology Group, Green Energy Technology Inc; Cells/Modules, Gintech, United Renewable Energy Corp, Motech, First Solar, JA Solar, Yingli, Trina Solar, Canadian Solar, PV Crystalox Solar, Hanwha Solar One, Jinko Solar, SunPower, LONGi, Tongwei; Inverters – SolarEdge; Enphase; SMA Solar; Advanced Energy Industries; Integrators - Real Goods Solar, SolarCity, Vivint Solar, Sunrun, Sunworks, Enlight Renewable Energy, Sunnova; IPP/Yieldco - Brookfield Renewable Partners; Algonquin Power & Utilities Corp; Clearwater Energy, Northland Power, Pattern Energy, Terraform Power, TransAlta Renewables. Data for Q4 2021 was not available for Enlight Renewable Energy, JA Solar, LONGi, Tongwei, Risen, and Trina Solar; TTM was used in place of yearly values for all but JA Solar for which yearly data were not available.

Operating Margin Across Supply Chain

- System integrator companies lost money on average in 2021, but they did narrow their losses. Polysilicon firms had positive operating margins for the first time in 2 years.

- Yieldcos have historically had positive operating margins (which continued in 2021), but their margins have decreased for 3 years straight.
- Wafers and polysilicon were the only ones to increase their operating margins in 2021 over 2020. Cells/modules and inverters both saw slight decreases in profitability in 2021.



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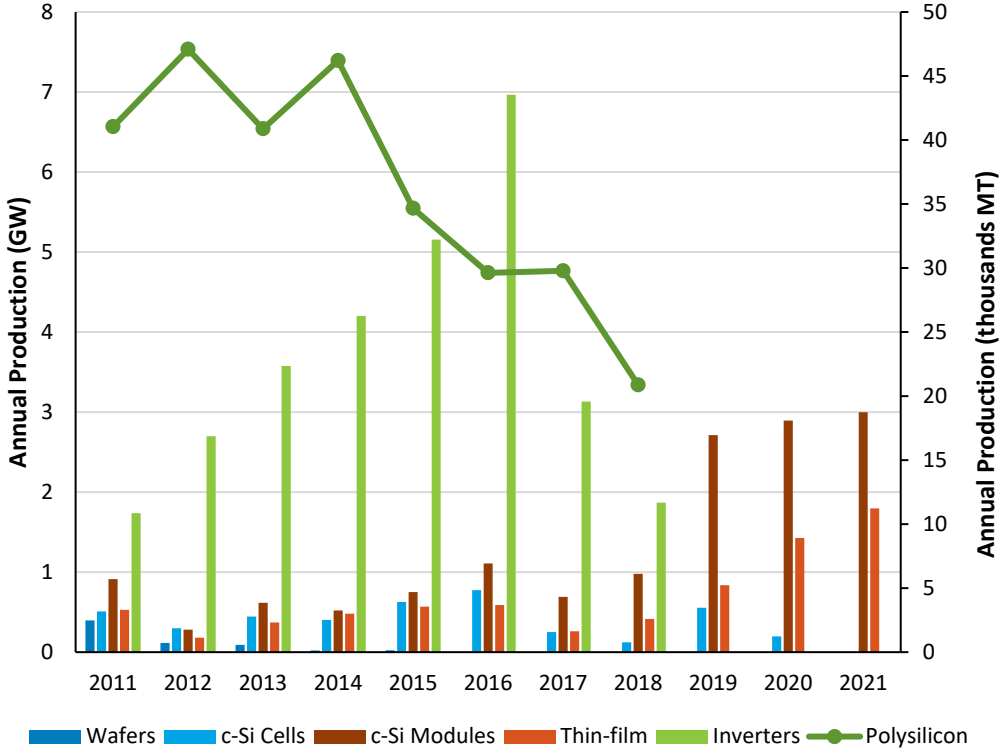
U.S. Module and Cell Manufacturing



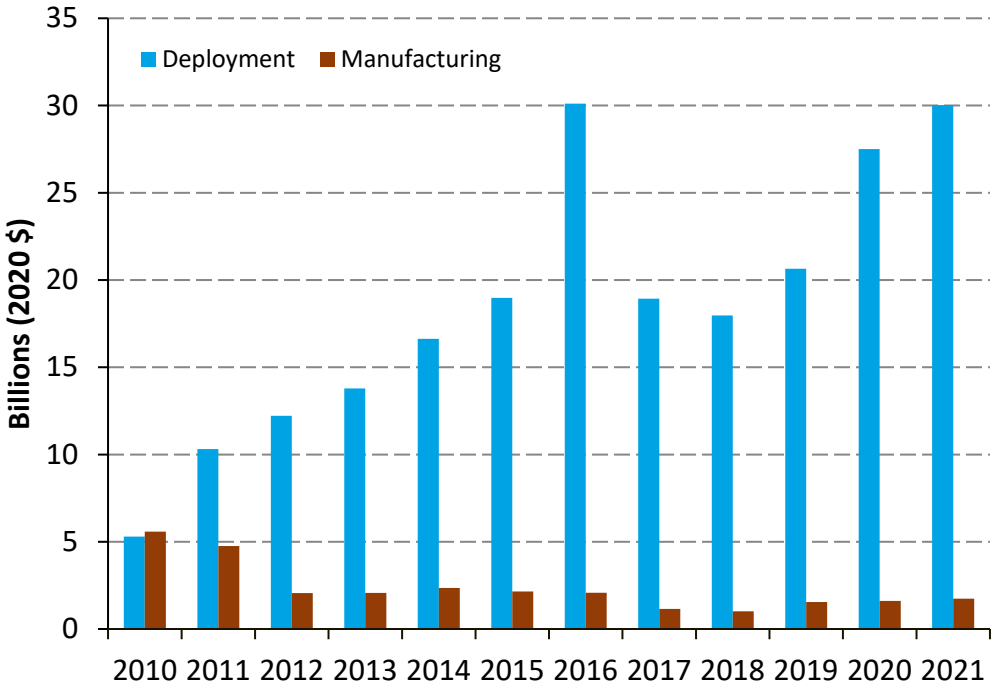
From 2011 to 2021, U.S. manufacturers faced varying degrees of challenges.

- Wafer production in the United States ended in 2015, cell production ended in 2021, and it is unclear whether any solar-grade polysilicon is being produced domestically.
- U.S. inverter manufacturing grew with increasing U.S. demand; however due to economic pressures, many manufacturers closed U.S. plants to consolidate operations in Europe or to manufacture in China.
- PV-assembled modules stagnated for most of the past decade before scaling up significantly in 2018 and 2019.
  - In 2021, the United States produced a record 4.8 GW of PV modules, up 11% y/y, mostly as a result of a 25% increase in production by First Solar.
  - Annual production of c-Si modules has continued to grow in 2020 and 2021, although at a much slower rate.

Additional parts of the U.S. PV manufacturing supply chain such as racking, glass, laminates, and backsheets are not covered here.

Source: Wood Mackenzie Power & Renewables & SEIA, "U.S. Solar Market Insight" (2014–2021).

Revenue of U.S. PV



- The last time revenue from PV manufacturing was greater than revenue from PV deployment was in 2010. Since then, deployment revenue has generally increased as manufacturing revenue declined.
- In 2021, revenue from PV deployment was 17x revenue from PV manufacturing.
- Despite a record level of PV module assembly, revenues from U.S. PV manufacturing in 2021 was approximately one-third of 2011 levels.
  - PV equipment was significantly cheaper in 2021 than it was in 2011.
  - More than half of 2010 U.S. revenues came from polysilicon, wafers, and cells, all of which ceased production by the end of 2020.
- Similarly, despite a record level of U.S. PV deployment, revenue from PV system sales in 2021 just barely beat the record revenue from 2016, due to the falling price of PV systems.

Source: Wood Mackenzie Power & Renewables & SEIA, "U.S. Solar Market Insight" (2014–2021), BLS, NREL Cost Benchmark.

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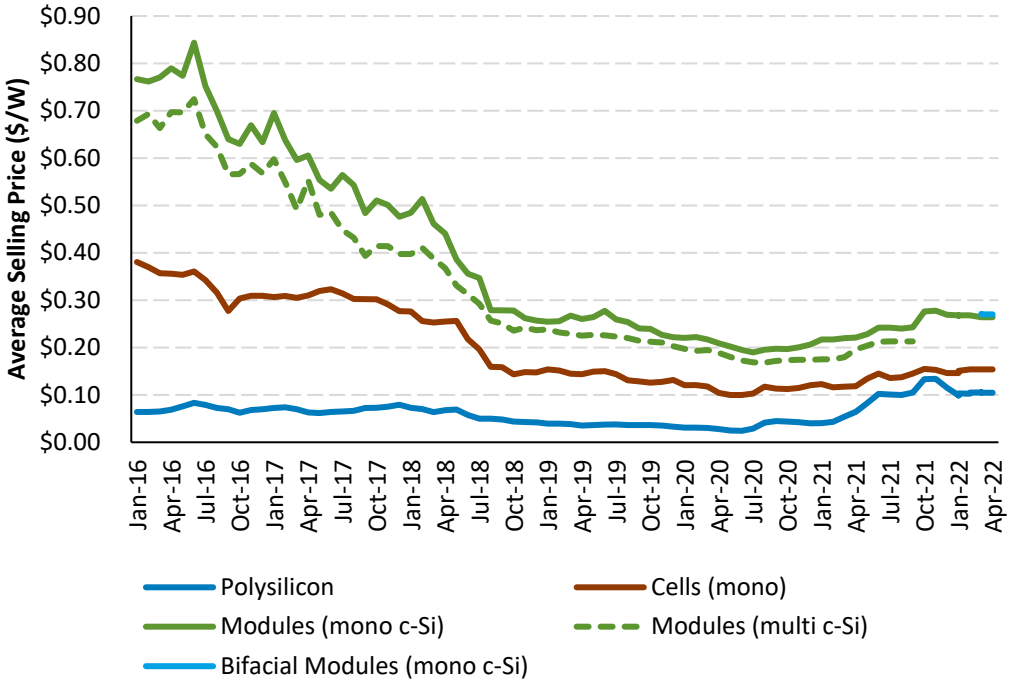
- **Following a peak above $37/kg in November, polysilicon spot prices declined before rising 6% to $34/kg through the first 3 months of 2022.**
  - The 2022 increase was due to demand from wafer makers, while supply from new polysilicon factories continued to ramp up.
- **Module prices fell 1% through the first 3 months.**
  - Weak module demand from China outweighed strong demand from other markets (e.g., the EU and India).
  - Module producers faced higher material prices without raising their prices.
- **In Q4 2021, U.S. mono c-Si module prices rose $0.01/W, y/y, and were flat q/q— trading at a 46% premium over global ASP.**

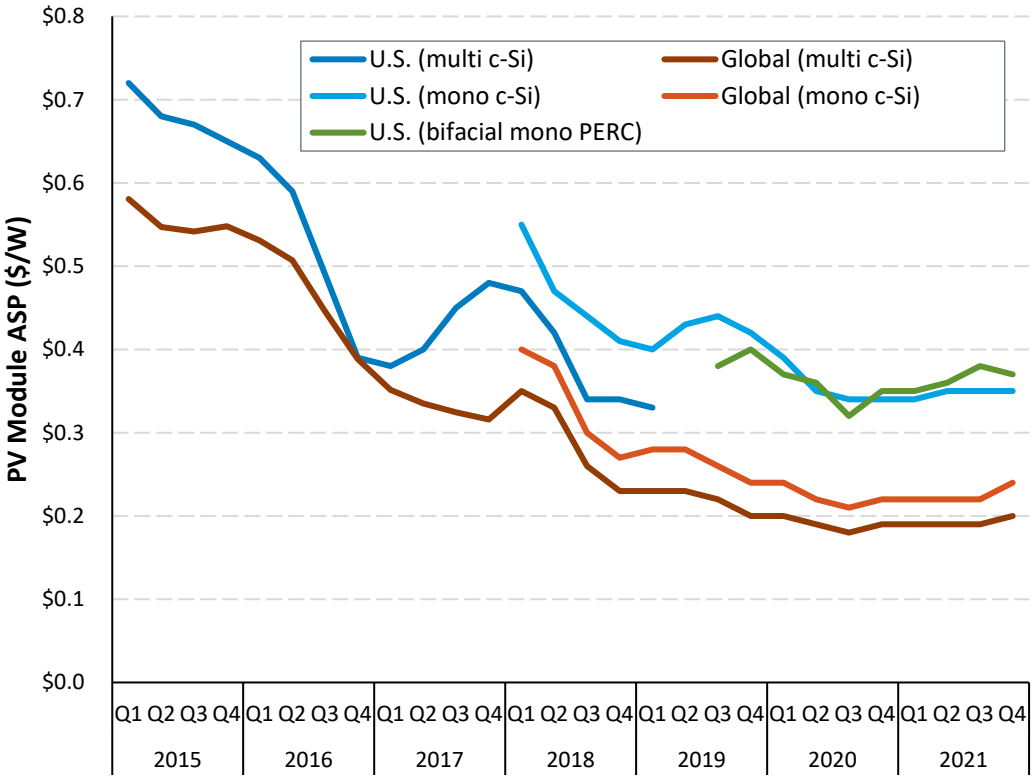
PV Value Chain Spot Pricing



Source: BloombergNEF Solar Spot Price Index (4/7/22); BloombergNEF Bimonthly PV Index (3/18/22).
Kilogram to Watt Conversion: 4.78 grams per watt (2016); 4.73 grams per watt (2017), from Cowen & Co. (05/11/17) add Deutsche Bank (07/19/17); 4.35 (2019); 4.10 (2019); 3.85 (2020); 3.60 (2021); 3.1 (2022) from Bernreuter.

- Following a peak above $37/kg in November, polysilicon spot prices declined before rising 6% to $34/kg through the first 3 months of 2022.
  - A spike in silicon feedstock metal price and concerns about a power shortage in China drove the November peak.
  - The 2022 increase was due to demand from wafer makers, while supply from new polysilicon factories continued to ramp up.
- Cell prices rose 5% through the first 3 months of 2022 in step with strong wafer demand and rising wafer prices.
- Module prices fell 1% through the first 3 months.
  - Weak module demand from China outweighed strong demand from other markets (e.g., the EU and India).
  - Module producers faced higher material prices without raising their prices.

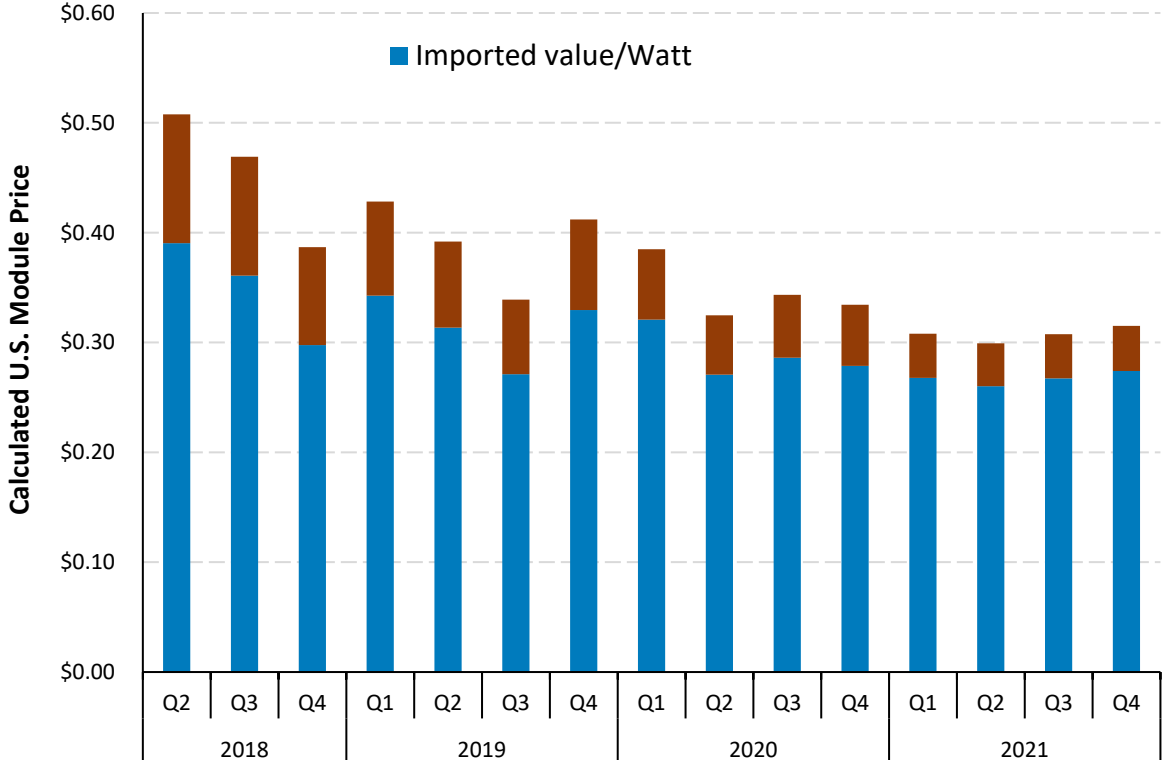
Module Average Selling Price: Global versus United States



- In Q4 2021, U.S. utility-scale monofacial mono c-Si module prices (delivered from Southeast Asia) rose $0.01/W, y/y and were flat q/q, trading at a 46% premium over global ASP.
- The price premium of U.S. bifacial mono c-Si modules over monofacial counterparts shrank to about $0.015/W.
  - The bifacial exemption to the Section 201 tariffs—which was removed in Q4 2020—was reinstated in Q4 (late November) 2021.
- Global mono and multi c-Si module prices rose by about 10% from Q3 to Q4 2021.
- Continuing high material costs, supply chain constraints, and high shipping costs put upward pressure on prices.

Source: Wood Mackenzie Power & Renewables/SEIA.

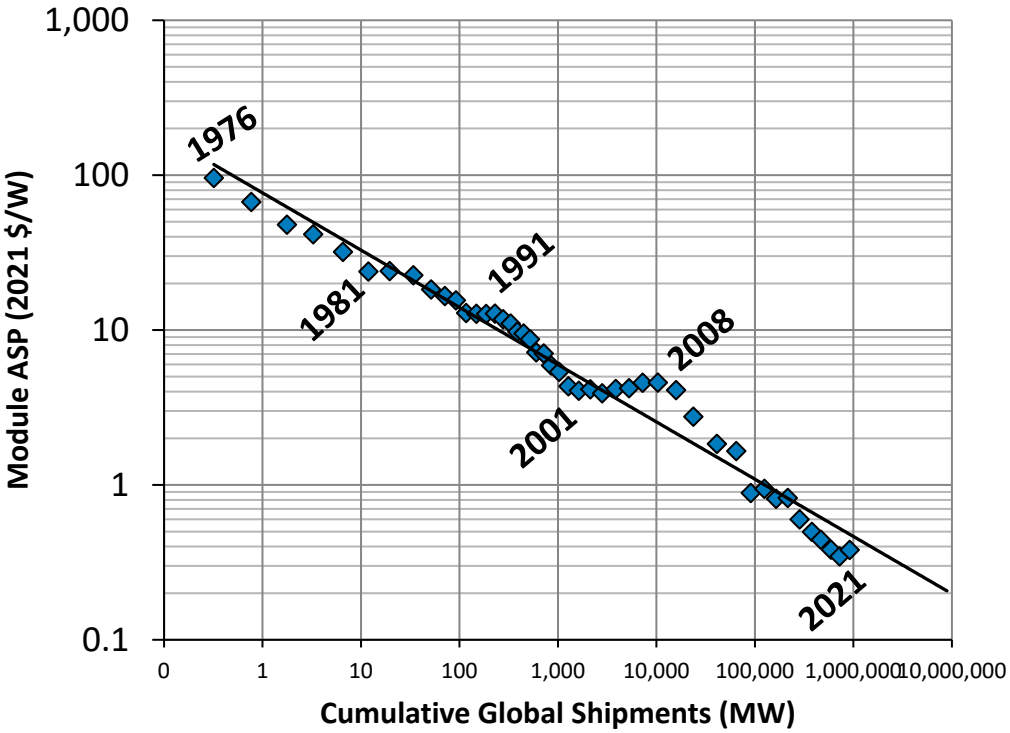
Calculated U.S. Module Pricing



- Based on the reported value and capacity of imported PV modules, the average price of a PV module in the United States before tariffs dropped from $0.39/W in Q2 2018 to $0.27/W in Q4 2021.
- The average price has held quite steady for all of 2021 (± $0.01/W) .
- And as a result of the underlying price reduction and step-down of the Section 201 tariff, these duties have been cut by 67% on a per-watt basis (from approximately $0.12/W to $0.04/W).

Source: Imports, by value and megawatt: U.S. International Trade Commission, 2018-2021.

PV Experience Curve



- This solar PV experience curve, known as Swanson's Law, displays the relationship, in logarithmic form, between the average selling price of a PV module and the cumulative global shipments of PV modules.
- For every doubling of cumulative PV shipments from 1976 to 2021, there has been on average a ~23% reduction in PV module price.
- Since 2008, the PV industry has experienced accelerated improvements, putting module ASPs below the historical experience curve since 2012.
  - In 2021, module pricing was $0.38/W, which was well below what the historical experience curve would have suggested ($0.48/W).

Source: SPV Market Research. Report SPV-Supply10. April 2022.

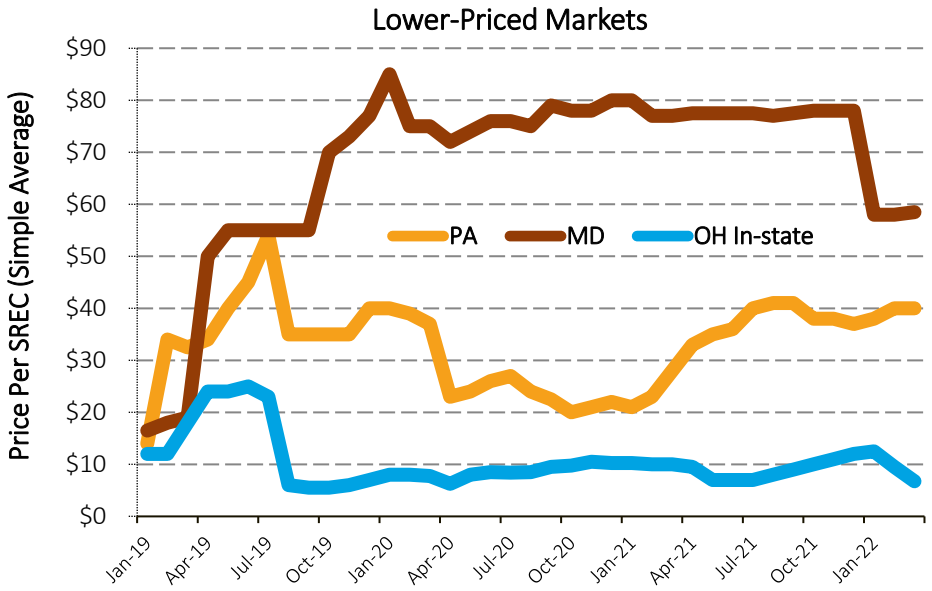
Agenda

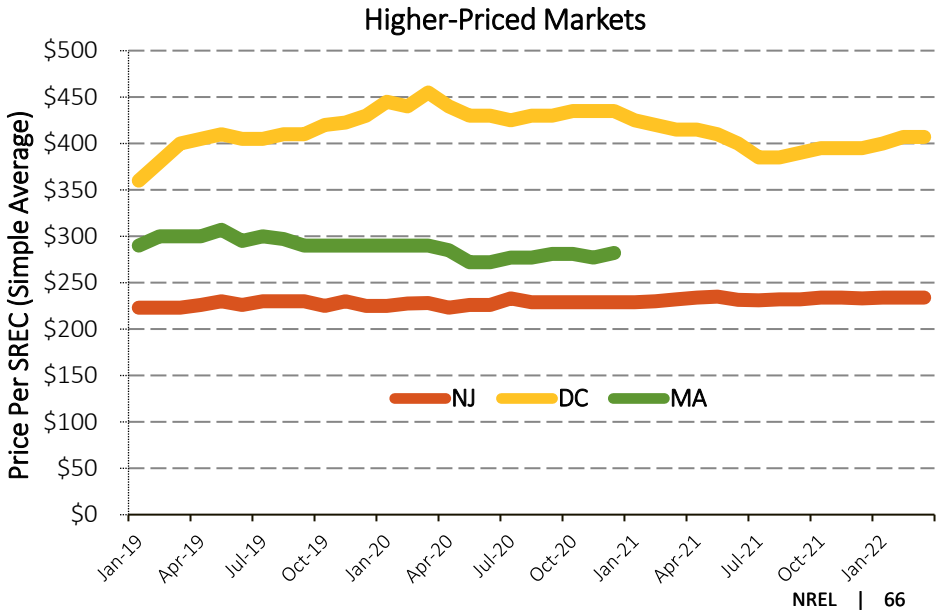
1. Global Solar Deployment
2. U.S. PV Deployment
3. PV System Pricing
4. Global Manufacturing
5. Component Pricing
6. **Market Activity**
7. U.S. PV Imports

- **Solar stocks started 2022 by continuing last year's downward trend, with the Invesco Solar ETF dropping 24% in the first two months.**
- **Solar stock prices rebounded, however, as reactions to Russia's invasion of Ukraine on February 24 increased fossil fuel prices along with demand for renewable energy investments. Between the start of the invasion and April 1, the Invesco Solar ETF rose 18%, despite continued concern about the effect of supply chain constraints on solar company earnings.**

SREC Pricing

- The graphs reflect a change from 2021 to 2022 SREC bids, accounting for Maryland's price decline; Maryland's 2021 SRECs were priced $20 higher than 2022 SRECs during the quarter due to a higher alternative compliance payment for 2021.
- Otherwise, SREC prices stayed relatively flat in the past quarter.
- Active SREC programs have closed in New Jersey, Massachusetts, and Ohio.

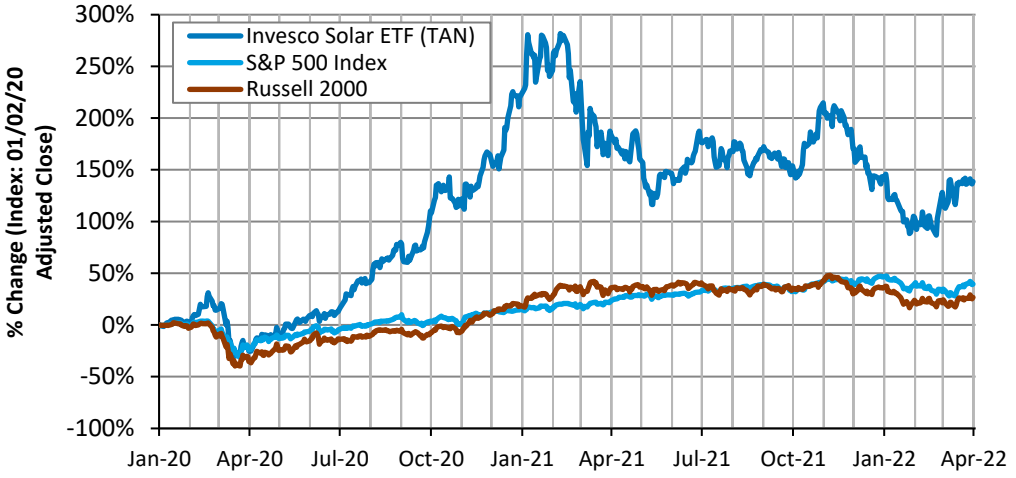




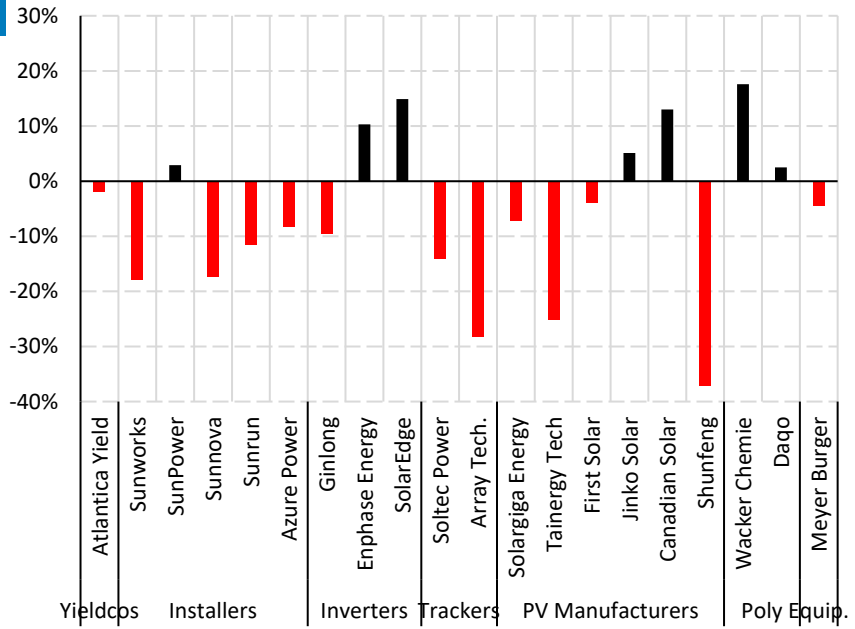
Source: SRECTrade, https://www.srectrade.com/, accessed 3/14/22.

Stock Market Activity

- Solar stocks started 2022 by continuing last year's downward trend, with the Invesco Solar ETF dropping 24% in the first 2 months.
- Solar stock prices rebounded, however, as reactions to Russia's invasion of Ukraine on February 24 increased fossil fuel prices along with demand for renewable energy investments. Between the start of the invasion and April 1, the Invesco Solar ETF rose 18%, despite continued concern about the effect of supply chain constraints on solar company earnings.



Individual Stock Performance (Q1 2022)



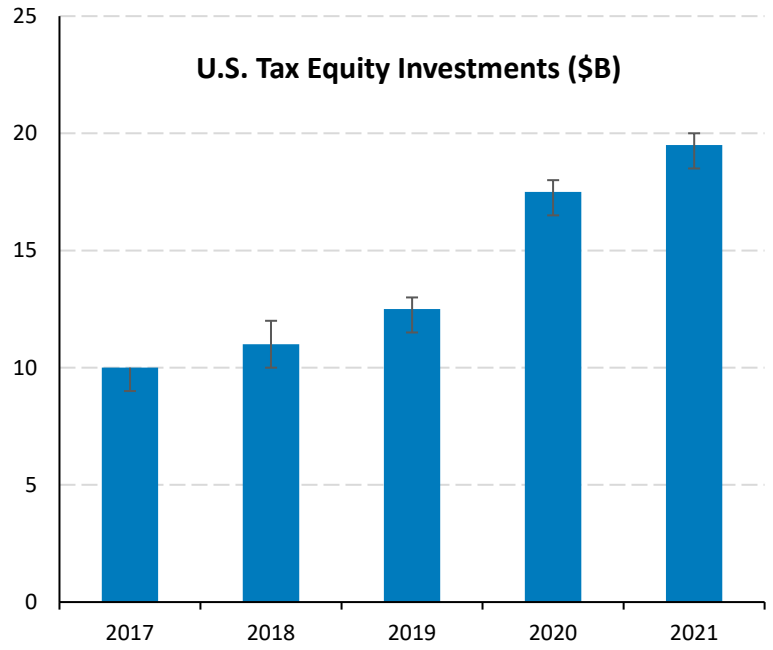
Note: The TAN index is weighted toward particular countries and sectors. As of 4/4/22, 47% of its funds were in U.S. companies, with 24% in Chinese companies. Its top 10 holdings, representing 56% of its value, were Enphase, SolarEdge, Sunrun, Xinyi, First Solar, Daqo, Shoals Technologies, GCL-Poly Energy, Hanwha, and Sunnova.

Sources: Markets Insider (3/8/22). Yahoo Finance (3/2/22). Forbes (3/9/22). Stock market: Yahoo Finance (4/4/22).

Cost of Capital, 2021

Tax Equity

- Tax equity investors invested $19 billion–$20 billion in 2021—roughly double 2017 investments. However, supply chain issues and customs seizures of PV modules moderated demand in 2021.
- Tax equity demand for 2022 is exceptionally strong for solar and solar-plus-storage projects
- Tax equity represented roughly 35% of solar project costs in 2020 and 2021 (±5%), but this could change if pieces of the Build Back Better legislation are passed.
- Tax equity flip yields (i.e., the rate of return a tax equity investor receives before they become a minority interest in the project) increased from 6.0%–6.5% in 2020 to 6.75%–7.5% in 2021.
- Investors are becoming more interested in indexing investment returns and PPAs, rather than seeking absolute values, due to uncertainties in costs, policy, and international conflicts. Investors are also worried increases in interest rates, raw materials, and international shipping costs will increase project costs.
- Price increases also make tax credit value more uncertain as it is more difficult to satisfy having purchased at least 5% of project costs to qualify for a project as having begun construction.



Debt

- Projects with standard contracts and high credit offtakers are receiving loan terms of LIBOR plus 112.5 basis points, compared to last year when the low end of the range was 125 basis points.
- Short-term construction bridge loans are now as tight as LIBOR plus 60–70 basis points for 1-year contracts.
- Loan tenors remain 5–7 years (though some are as long as 19 years) with solar projects getting DSCRs of 1.25.

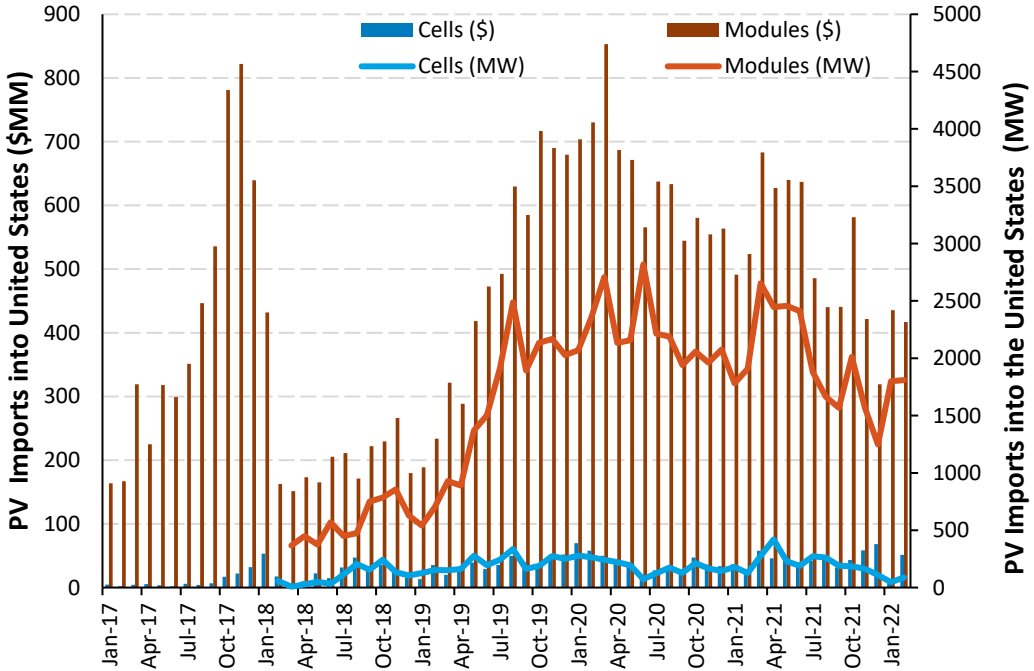
Sources: Norton Rose Fulbright Cost of Capital: 2022 Outlook.

Agenda

1. Global Solar Deployment
2. U.S. PV Deployment
3. PV System Pricing
4. Global Manufacturing
5. Component Pricing
6. Market Activity
7. **U.S. PV Imports**

- **On February 4, 2022, Section 201 tariffs on c-Si modules and cells were extended for another 4 years at just below 15%. Bifacial modules will remain exempt as will be the first 5 GW of cells.**
- **On April 1, 2022, Commerce initiated an investigation into whether Chinese companies are circumventing AD and CVD duties by manufacturing cells and modules in Southeast Asian countries.**
  - The inquiry could last a year and it has been reported that it is severely limiting the supply of modules to the United States.
- **In 2021, PV modules imports dropped 12% y/y to 23.6 GW.**
  - Some of the demand is likely due to developers attempting to "safe harbor" panels to get the 26% ITC (before it was extended).
  - More than half of the panels did not report a duty, likely because of the exemption from Section 201 tariffs for bifacial modules.
- **With 5.8 GWdc of annual c-Si PV module assembly capacity, 2.6 GWdc of imported cells in 2021 implies a 45% utilization rate.**
- **In addition to imports, First Solar produced approximately 1.8 GW of CdTe thin film modules.**
- **Collectively, Malaysia, Vietnam, Thailand, and Cambodia represent 77% of all c-Si imports.**

Module and Cell Import Data



- 23.6 GWdc of PV modules were imported into the United States in 2021, down 12% y/y.
  - Q4 2021 shipments were down 21%, y/y.
- 2.6 GWdc of cells were imported in 2021, up 17%.
- In addition to imports, First Solar produced approximately of 1.8 GWdc of CdTe PV modules in the United States in 2021.

Note: We adjusted Thailand's reported imports in megawatts for February 2021 and Turkey's imports in megawatts for January of 2022 because of likely reporting errors.

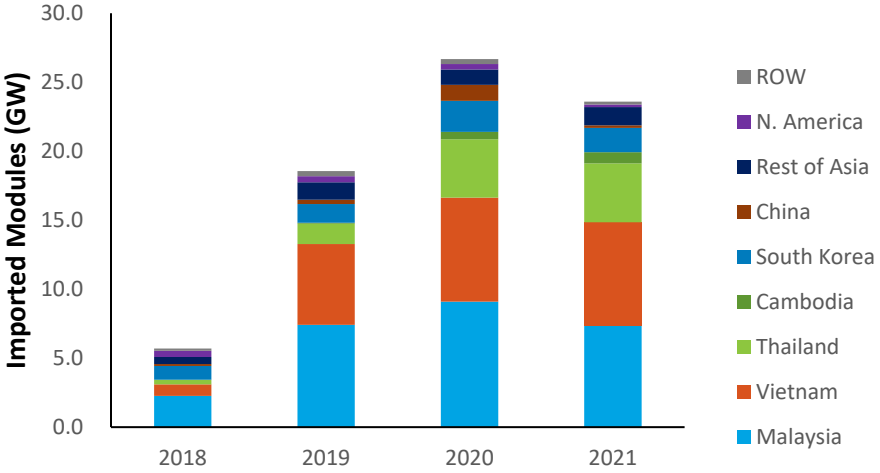
Sources: First Solar public filings; imports, by value and MW: U.S. International Trade Commission, 2016-2021.

Module and Cell Imports by Region

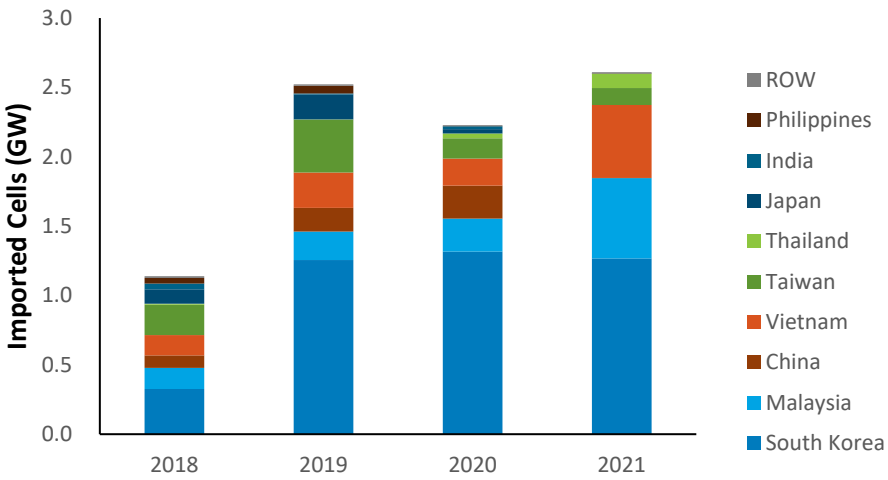
- Module imports in the United States shrank in 2021, mainly as a result of decreased imports from Malaysia (-19% y/y, -1.4 GW), South Korea (-22% y/y, -0.4 GW), and China (-85% y/y, -0.2 GW).

- U.S. PV cell imports grew 17% y/y in 2021, roughly matching 2019 PV cell imports.
  - China dropped from 236 MW PV cells in 2020 to <2 MW in 2021, with the difference mainly being made up by increased imports from Malaysia, Vietnam, and Thailand.

U.S. Module Imports by Region



U.S. Cell Imports by Region

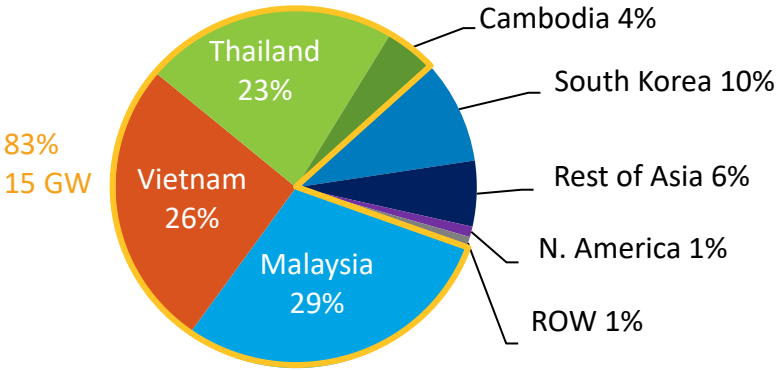


Note: Cell data uses HTS codes: 8541406030, 8541406025; module data uses codes: 8541406015, 8541406020, 8541406035. January and February 2018 module data unavailable.
Sources: Imports, by value and MW: U.S. International Trade Commission, 2021.

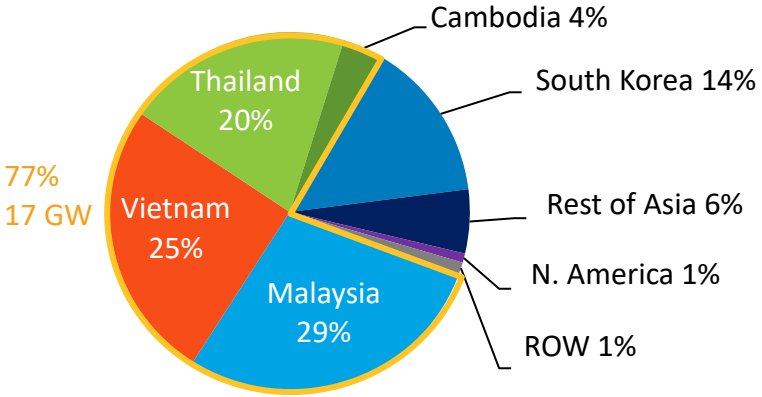
c-Si Module and Cell Imports by Region

- Collectively, Malaysia, Vietnam, Thailand, and Cambodia represent
  - 83% of c-Si modules (15 GW) imports and 46% of c-Si cells (1.2 GW) imports, or
  - 78% of cells imported as either cells or already incorporated into modules (17 GW).
- c-Si module imports decreased 18% y/y in 2021, mainly as a result of decreased imports from Malaysia (-29% y/y, -2.1 GW), Vietnam (-6% y/y, -0.5 GW), and South Korea (-22% y/y, -0.4 GW).

2021 U.S. c-Si Module Imports by Region (18.6 GW)

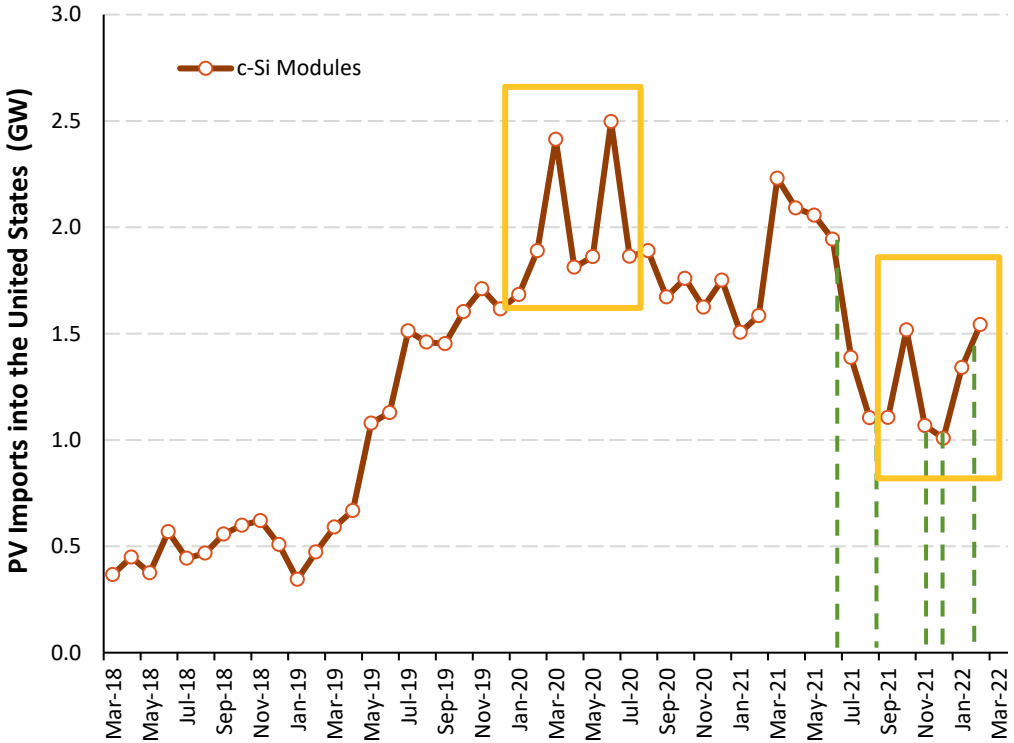


2021 U.S. c-Si Module + Cell Imports by Region (21.2 GW)



Note: Cell data uses HTS codes: 8541406030, 8541406025; module data uses codes: 8541406015, 8541406020, 8541406035.
Sources: Imports, by value and MW: U.S. International Trade Commission, 2021.

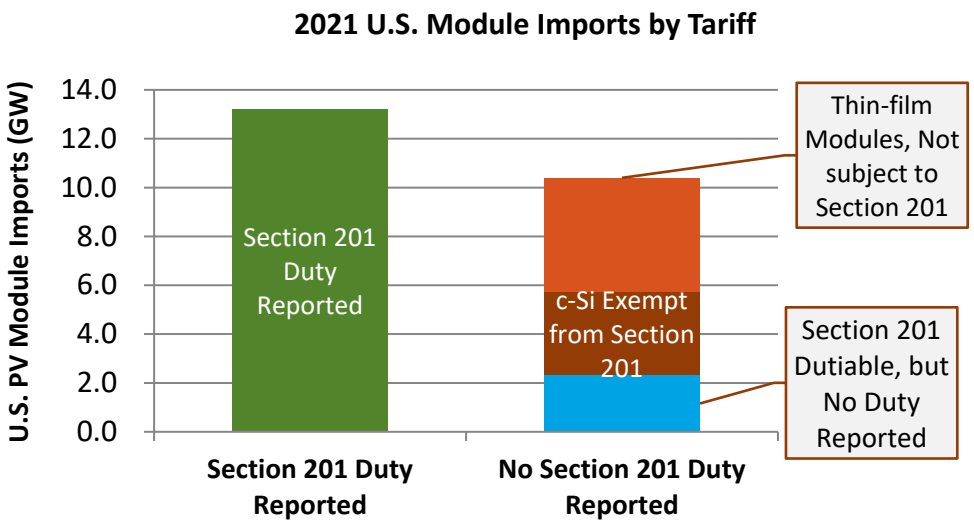
Impact of Withhold Release Order, AD/CVD Petition, UFLPA, and 201 Tariff Changes



- In November 2021,
  - Commerce dismissed a petition filed in August to issue antidumping and countervailing duties (AD/CVD) on solar cells from Southeast Asia (specifically Malaysia, Thailand, and Vietnam)
  - U.S. Customs and Border Protection (CBP) clarified policies regarding the enforcement of its withhold release order issued in June against silica-based products from Hoshine Silicon Industry Co. in China's Xinjiang region
  - The U.S. Court of International Trade reinstated the exemption for bifacial modules from the Section 201 tariffs and reduced the tariffs from 18% to 15%.
- In December, the Uyghur Forced Labor Prevention Act (UFLPA) was passed. The act, which specifically mentions polysilicon as a "high-priority sector" for enforcement, will fully enter into force in June 2022.
- In February 2021, the Section 201 tariffs were extended by the president, raising the TRQ from 2.5 GW to 5.0 GW and maintaining the bifacial exemption.
- The last 6 months of imports displayed a similar volatility to first 6 months of 2020.

Note: We adjusted Thailand's reported imports in megawatts for February 2021 and Turkey's imports in megawatts for January of 2022 because of likely reporting errors.
Sources: Imports, by Second Unit of Quantity (watts): U.S. International Trade Commission, 2016-2022; CBP and Commerce press releases, White House press releases.

2021 U.S. Module Imports by Tariff

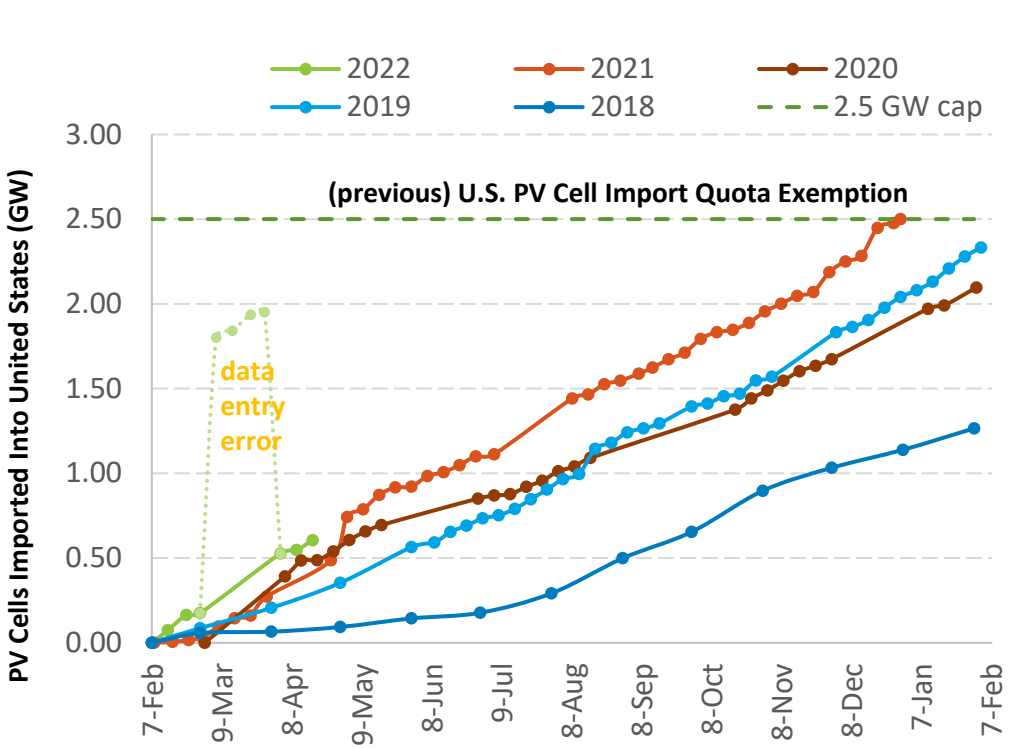


- In 2021, 13.2 GWdc of imported PV modules (56% of all PV module imports) reported a tariff.
- Most of the modules that did not were thin-film and not subject to tariffs or c-Si technology panels exempt from Section 201 tariffs (e.g., IBC cells).
  - For approximately 2.3 GW of imported c-Si modules—subject to Section 201—no duties were reported. Why this happened is unclear.
- In Q4, imports of c-Si panels exempt from Section 201 tariffs nearly doubled that of any of the individual previous quarters of the year (+1.2 GW vs. +0.7 GW).

Note: Module data uses codes 8541406015, 8541406020, and 8541406035. We assumed all modules not subject to Section 201 tariffs are reported under "Free under HS Chapters 1-98" or "Entered into U.S. Virgin Islands," with exemptions coming from HTS code 8541406015, and technologies not applicable reported under HTS code 854140603. We assume all panels subject to Section 201 duties have been reported under "Dutiable- HS chapter 99." We adjusted Thailand's reported imports in megawatts for February because of a likely reporting error.

Source: Imports, by MW: U.S. International Trade Commission, Oct 2021; USITC Commission Publications Library

Cell Import Data by Tariff



- The previous 2.5-GWdc quota exemption on the first 2.5 GWdc of imported c-Si PV cells each reporting year subject to the Section 201 tariff was raised to 5 GWdc in February.
  - The cap was hit on December 30, 2021, and all imports between that time and the renewal of the Section 201 tariffs were subject to 15% duties. According to USITC data, 135 MW of cells paid duties in January and February of 2022.
- A data entry error resulted in the percentage consumption of the quota exemption artificially jumping from 3.5% to 36.0% in a single week. The error was corrected the week of April 4 and the data are now on a similar pace to 2020/2021 imports.

Note: Cell data uses HTS codes 8541406025.
Sources: Imports, by MW: U.S. International Trade Commission, 2018-2021; U.S. Customs and Protection Commodity Status Reports Feb 2019 - Apr 2022.

Recent News on Section 201 Tariffs

Original Tariffs	2018	2019	2020	2021
Cell Quota Volume	2.5 GW	2.5 GW	2.5 GW	2.5 GW
Cell Tariffs below Quota	0%	0%	0%	0%
Cell Tariffs above Quota	30%	25%	20%	15%
c-Si Module Tariffs	30%	25%	20%	15%

*Bifacial modules were exempt, starting in June 2019 (though faced litigation to revoke the exemption starting in October 2019). The 2021 tariffs were also briefly raised to 18%.
**Year starts on February 7th and goes to February 6th of the next year

Original Tariffs	2022	2023	2024	2025
Cell Quota Volume	5.0 GW	5.0 GW	5.0 GW	5.0 GW
Cell Tariffs below Quota	0%	0%	0%	0%
Cell Tariffs above Quota	14.75%	14.50%	14.25%	14.00%
c-Si Module Tariffs	14.75%	14.50%	14.25%	14.00%

- On February 4, 2022, after receiving a recommendation from the USITC in November, President Biden extended the Section 201 tariffs on crystalline silicon modules and cells another 4 years.
- The tariffs remain largely unchanged from 2021, except for lifting the cell quota from 2.5 GW to 5.0 GW
  - The quota was designed to provide relief to module assembly in the United States but also encourage ramping up of U.S. PV cell manufacturing.
- The president determined that the bifacial exemption should remain in place.
  - Bifacial modules have recently captured a significant percentage of U.S. utility-scale market share, though bifacial modules could also be more economical than monofacial modules in distributed PV applications as well.
  - First Solar, whose technology is not applicable to the tariffs and who primarily services the utility-scale sector, strongly opposes the exemption.
- The safeguards also authorizes the USTR to negotiate an agreement with Mexico and Canada that may lead to a certain amount of PV cells and modules being imported from those countries without tariffs.

Recent News on AD/CVD Petition

- On February 8, 2022, Auxin filed a circumvention inquiry request alleging solar cells and modules completed in Cambodia, Malaysia, Thailand, or Vietnam using parts and components manufactured in China are circumventing U.S. tariffs. Pursuant to section 781(b) of the Tariff Act of 1930 (merchandise completed or assembled in other foreign countries), the following must be true:

  (A) Merchandise imported into the United States is of the same class or kind as any merchandise produced in a foreign country that is the subject of an AD order or finding or a CVD order;

  (B) before importation into the United States, such imported merchandise is completed or assembled in another foreign country from merchandise which is subject to the order or finding or is produced in the foreign country with respect to which such order or finding applies;

  (C) the process of assembly or completion in the foreign country referred to in subparagraph (B) is **minor or insignificant**;

  (D) the value of the merchandise produced in the foreign country to which the AD (or CVD) order applies is **a significant portion of the total value of the merchandise** exported to the United States; **AND**

  (E) the administering authority determines that action is appropriate to prevent evasion of such order or finding.

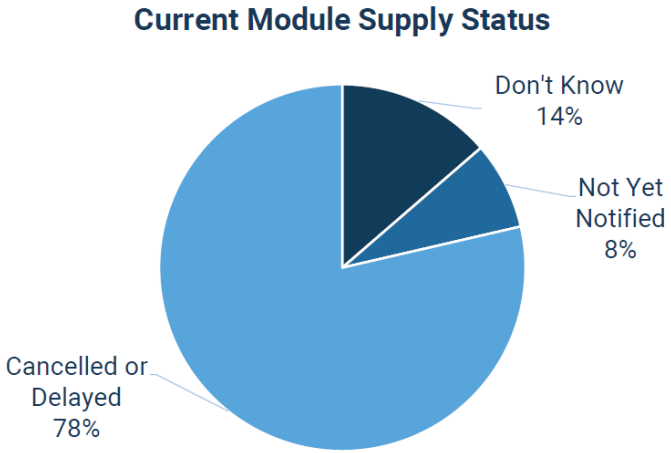
- On April 1, 2022, Commerce initiated country-wide circumvention inquiries on imports of crystalline silicon photovoltaic cells, whether or not they were assembled into modules (solar cells and modules), which are completed in Cambodia, Malaysia, Thailand, or Vietnam using parts and components from the People's Republic of China (China), are circumventing the AD and CVD orders on solar cells and modules from China.
  - Commerce will solicit information from certain companies in Cambodia, Malaysia, Thailand, and Vietnam concerning their production of solar cells and modules and their shipments thereof to the United States.
  - A preliminary determination in these circumvention proceedings will be issued in no later than 150 days.
  - Until an official determination is made, a cash deposit will apply at a rate that would be applicable if the products were determined to be covered by the scope of the AD/CVD.

- In a statement made on April 22 (Earth Day), it was announced that Commerce has been directed to integrate climate considerations into its policymaking.

Sources: 87 FR 19071.

Impact of Auxin AD/CVD Petition

- The investigation could last up to a year and, if Commerce rules in favor of the petition, tariffs of up to 250% could be levied on most cells and modules imported into the United States.
- SEIA surveyed 412 companies, a week after Commerce announced the opening of an investigation that Chinese companies are circumventing AD/CVD duties through manufacturing cells and modules in Southeast Asia.



- More than 90% of the companies polled said the Commerce Department's actions are having a severe or devastating impact on their bottom line, including 80% of domestic manufacturers.
- Over three-quarters of companies purchasing modules reported a canceled or delayed module supply due to the opening of the investigation. Roth Capital reported that solar facilities in Vietnam, Malaysia, and Cambodia, have started to reduce production.
- Two-thirds of respondents reported that at least 70% of their solar and storage workforce is at risk.
- 56% of respondents report at least 70% or more of their current-year solar pipeline at risk.
- 64% of energy storage respondents also reported severe or devastating affects because storage is currently so tied to solar.
- While the investigation is still ongoing, manufacturers and developers have concerns about retroactive duties back to April 2022, or perhaps November 2021, and large cash deposits which would be collected if there is an affirmative preliminary determination.
- Wood Mackenzie reported that the petition could eliminate 16 GW of panels from the U.S. supply chain, and SEIA reported that the solar industry would lose 70,000 of its 231,000 jobs.

Sources: PV Magazine (04/08/22);SEIA.

Current AD/CVD Duties

	Latest published Duties (%)				Estimated 2021 U.S. Market Share			
	AD	CVD	**AD/CVD Combined**	**W/ Section 301**	Utility-scale	Commercial	Residential	
First Solar					39%			U.S.
Jinko Solar	68.93	11.97	**80.9**	**105.9**	17%	9%	6%	China
Canadian Solar	0	11.97	**11.97**	**36.97**	9%	5%	2%	China
LONGi	0	11.97	**11.97**	**36.97**	8%	4%	15%	China
JA Solar	68.93	19.28	**88.21**	**113.21**	7%	11%	2%	China
Astroenergy (Chint)	0	4.22	**4.22**	**29.22**	5%	2%		China
Hanwha	?	?			5%	21%	24%	S. Korea, China
Waaree					5%			India
VSUN (Sunergy)	?	?			2%	2%	0%	Vietnam, China
Trina	50.33	11.97	**62.3**	**87.3**		9%	1%	China
Risen	0	10.86	**10.86**	**35.86**		1%		China
GCL	0	11.97	**11.97**	**36.97**		1%		China
Talesun	52.13	38.43	**90.56**	**115.56**		1%		China
Yingli	0	11.97	**11.97**	**36.97**			0%	China
SunPower (Maxeon)						8%	11%	Singapore

- Current AD/CVD duties vary widely by company, with the largest tariffs levied on Jinko Solar, JA Solar, Trina, and Talesun. These companies represent approximately one-quarter to one-third of 2021 U.S. utility-scale and commercial PV installations.
- However, c-Si producers with smaller AD/CVD duties, are still subject to an additional 25% duty from Section 301 (as well as an additional 15% for non-bifacial panels, from Section 201).
- Additionally, there is great uncertainty in the AD/CVD final rates, as they are often decided several years after the shipments occurred. These rates have changed dramatically in both directions.
- 39% of the 2021 U.S. utility-scale market from First Solar, which is not subject to the duties, and another ~12% may not be subject as well.
- For distributed U.S. PV systems, there is significant U.S. module assembly capacity, with over half of cell shipments coming from South Korea (as well as Japan, India, and the Philippines).

Thank You

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NREL/PR-7A40-82854

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List of Acronyms and Abbreviations

a-Si: amorphous silicon
AD: antidumping
AEO: Annual Energy Outlook
ASP: average selling price
BNEF: Bloomberg New Energy Finance
BIPV: building-integrated photovoltaics
CBP: U.S. Customs and Border Protection
C&I: commercial and industrial
c-Si: crystalline silicon
CdTe: cadmium telluride
CIGS/CIS: Copper indium gallium selenide
CSP: concentrating solar power
CVD: countervailing
dc: direct current
DER: distributed energy resource
DG: distributed generation
DOE: U.S. Department of Energy
DPV: distributed PV
DSCR: debt-service coverage ratio
EIA: U.S. Energy Information Administration
ETF: exchange traded fund
EU: European Union
G&A: general and administrative expenses
GW: gigawatt
GWh: gigawatt-hour
H1: first half of year
H2: second half of year
HJT: heterojunction technology
HIT: heterostructure with intrinsic thin layer
HTS: harmonized tariff schedule
IBC: interdigitated back contact
IEA: International Energy Agency
IOU: investor-owned utility
IPP: independent power producers
kg: kilogram
kW: kilowatt
kWh: kilowatt-hour
LNG: liquified natural gas
mono c-Si: monocrystalline
multi c-Si: multicrystalline
MW: megawatt
Mwe: megawatt-energy
MWh: megawatt-hour
MWp: megawatt-peak
MWth: megawatt-thermal
NEM: net energy metering
NREL: National Renewable Energy Laboratory
NYSERDA: New York State Energy Research and Development Authority
OECD: The Organisation for Economic Co-operation and Development
PERC: passivated emitter and rear contact
PV: photovoltaics
ROW: rest of world
RPS: renewable portfolio standard
Q: quarter
SEIA: Solar Energy Industries Association
SFS: Solar Futures Study
SMART: Solar Massachusetts Renewable Target
SREC: solar renewable energy certificate
TAN: Invesco Solar ETF
Topcon: tunnel oxide passivated contact
TOU-E: time-of-use energy
TRQ: tariff-rate quota
TTM: trailing twelve months
TW: terawatt
TWh: terawatt-hour
UFLPA: Uyghur Forced Labor Prevention Act
UPV: utility-scale PV
USITC: U.S. International Trade Commission
USTR: United States Trade Representative
W: watt
y/y: year over year
YTD: year to date