NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Winter 2023 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

- China's National Energy Administration revealed in late January that China installed 87 GW in 2022, up 59% y/y.
  - In the first 9 months of 2022 PV, installations increased significantly (y/y) in China (106%) and India (51%), and to a lesser extent in Germany (22%).

U.S. PV Deployment

- The California Public Utilities Commission approved revised net metering rules in December 2022 — becoming effective in April 2023 — with exported solar energy eventually being compensated at rates ~75% lower than retail. Unlike the previous proposal, there are no fixed charges and there is a transition period.
- The United States installed 11.2 GWac (13.4 GWdc) of PV in the first three quarters of 2022—down 9% from the first three quarters of 2021.
- The United States installed approximately 11.1 GWh (3.7 GWac) of energy storage onto the electric grid in Q1–Q3 2022, +88% (+90%) y/y, as a result of high levels of residential deployment and grid-scale deployment.

PV System and Component Pricing

- From H2 2021 to H2 2022 (partial), the median reported distributed PV system price in Arizona, California, Massachusetts, and New York increased 4% to $4.25/Wdc for systems 2.5 to 10 kW but decreased 3% to $1.77/Wdc for systems 500 kW to 5 MW.
- Polysilicon global spot prices began Q4 2022 around $37/kg but dropped 40% (to $22/kg) by mid-January, the lowest price in 1.5 years.
- Global wafer and cell prices dropped by 40%–50% during this period.
- Global module prices fell only around 10% as demand from Europe decreased but Chinese demand remained relatively strong.
- In Q3 2022, the average U.S. module price ($0.43/Wdc) was up 14% q/q and up 30% y/y, trading at a 63% premium over the global spot price for monofacial monocrystalline silicon modules.

Global Manufacturing

- In H1 2022, U.S. c-Si module production was at approximately the same level as in H1 2019, and thin-film (i.e., CdTe) production had grown by 3× (and increased 31%, y/y).
- Since the IRA's passage, over 85 GWdc of manufacturing capacity has been announced across the solar supply chain, including 19 separate new manufacturing plants.
- In December, the U.S. Department of Commerce issued a preliminary decision to impose anti-circumvention duties on some solar panels and cells produced in Vietnam, Malaysia, Thailand, and Cambodia. A final determination is due May 1, 2023.
- Several leading global PV companies announced expansion corporate production capacity to 50 GW or greater by 2023.

U.S. PV Imports

- 18.3 GWdc of PV modules were imported into the United States in the first 9 months of 2022, down 2% y/y.
- 1.8 GWdc of cells were imported in the first 9 months of 2022, down 18% y/y.

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

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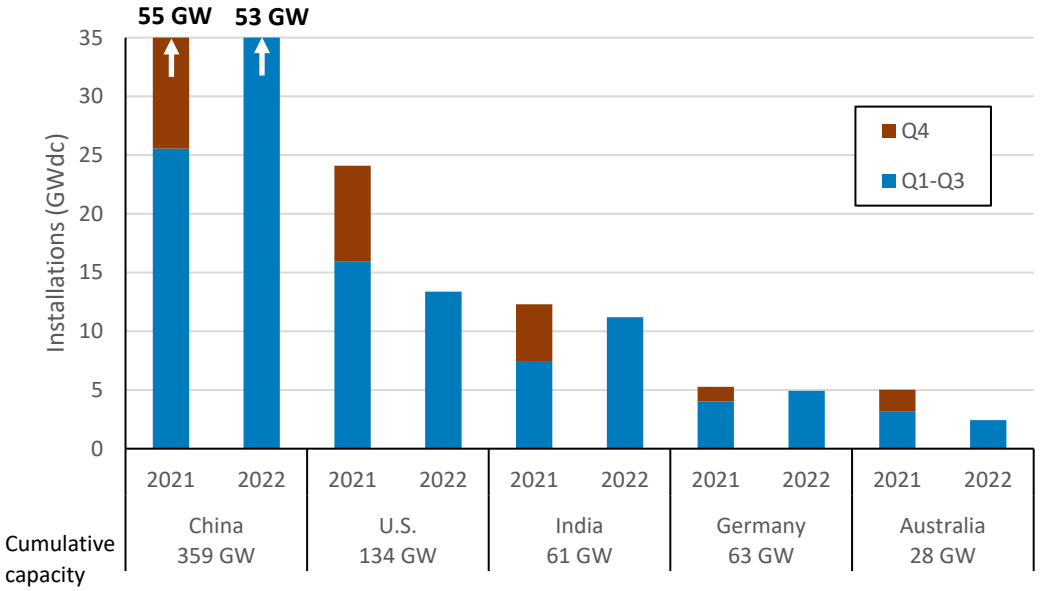
- **China's National Energy Administration revealed in late January that China installed 87 GWdc in 2022, up 59% y/y.**
  - **In the first 9 months of 2022 PV installations increased significantly (y/y) in China (106%) and India (51%), and to a lesser extent in Germany (22%).**
- **It was reported that the 100 MWac Urat CSP project, in Mongolia, China—with 10 hours of storage—generated 12 straight days of continuous power (June 4–15, 2022).**
  - **China typically needs more 24-hour power than other nations due to a higher percentage of load from overnight factory operations.**

International Q1–Q3 2022 Installations



- In the first 9 months of 2022, PV installations increased significantly (y/y) in China (106%) and India (51%), and to a lesser extent Germany (22%).
  - China's National Energy Administration revealed in late January that China installed 87 GW in 2022, up 59% y/y.
- From a historical perspective, the United States and Australia also had very sizeable installation levels in the first 9 months of 2022, but they were down y/y in large part due to supply chain disruptions and price increases.
- At the end of September, these countries had cumulatively installed 644 GWdc of PV.

Sources: Australian Photovoltaic Institute. Clean Energy Associates PV Supplier Market Intelligence Report Q2 2022; IEEFA (07/21/22). Mercom (02/28/22, 10/03/22, 11/07/22. 01/23/23). PV Magazine (08/08/22, 07/22/22, 12/01/22); Wood Mackenzie/SEIA: U.S. Solar Market Insight: Q3 2021; Reuters (07/21/22).

CSP Update

- Crescent Dunes, the 110 MWac CSP plant with 10 hours of storage in Nevada, which was originally placed in service in 2015, continues to optimize operation, following its 2020 bankruptcy. Despite NV Energy terminating its PPA with the project in 2019, the utility continues to take its power.
  - The project operated less than half the year in 2021 and 2022, but it achieved capacity factors of 28% (October 2022) and 30% (November 2022).
- It was reported that the 100 MWac Urat CSP project, in Mongolia, China with 10 hours of storage, generated 12 straight days of continuous power (June 4–15, 2022).
  - China typically needs more 24-hour power than other nations due to a higher percentage of load from overnight factory operations.
- Panatère, a watch component manufacturer and steel recycling business, located in Switzerland, announced it would soon begin operating a solar furnace that melts steel without fuel or electricity.
  - The solar furnace can melt 400 tons of recycled steel per year and reach temperatures of 2,000° C.

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- **The United States installed 11.2 GWac (13.4 GWdc) of PV in the first three quarters of 2022—down 9% from the first three quarters of 2021.**
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Q4 2022 State Updates

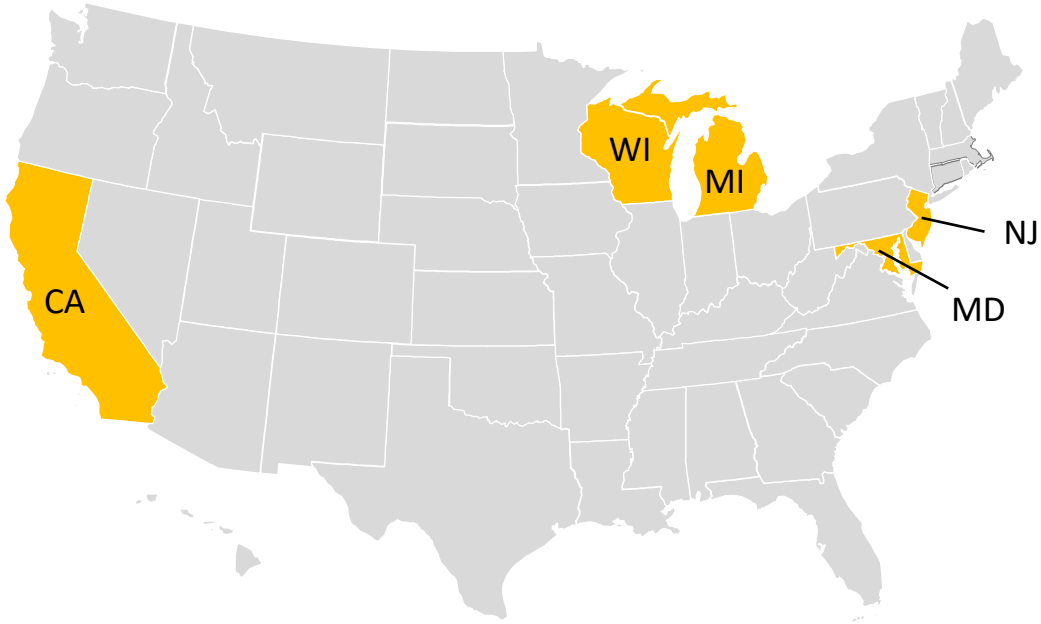
New Jersey—The public utilities commission established a competitive solar incentive program for grid-supply solar and storage and nonresidential net-metered solar larger than 5 MW, targeting at least 300 MW of capacity added each year through 2026.

California—Regulators approved a plan to achieve statewide carbon neutrality by 2045, which will entail quadrupling wind and solar energy, electrifying new buildings, and capturing carbon emissions.

Wisconsin—The public utilities commission ruled that a family could purchase solar power from a third-party installer, stating that this arrangement did not constitute an illegally competing public utility. Whether the ruling will open the state's third-party solar market broadly remains in question.

Michigan—The public utilities commission rejected a utility plan to impose demand charges on rooftop PV customers and reduce compensation for PV electricity, stating that a cost shift from PV customers onto non-PV customers was not proven and that the utility improperly evaluated the benefits of PV.

Maryland—The state's most populous county banned natural gas heating and cooking in new buildings, likely by 2027, to accelerate building electrification—the first county on the East Coast to do so.



Source: AP (12/19/22), E&E News (11/30/22, 12/2/22), New Jersey Board of Public Utilities (12/7/22), PV Magazine (11/21/22, 12/5/22, 12/8/22), Utility Dive (12/2/22)

California Adopts Net Metering 3.0 Policy

Comparison of California NEM Policies, Residential PV

	NEM 2.0 (2016)	NEM 3.0 Initial Proposal (Dec. 2021)	NEM 3.0 revised/adopted rule (Dec. 2022)
PV export rate	Retail, $0.30–$0.40/kWh	Avoided cost, ~75% lower than retail	Avoided cost, ~75% lower than retail
Monthly PV charge	None	$30–$40 (net of 10-y transition credit)	None
Export adder	None	None	$0–$0.04/kWh for 9 y for typical systems installed in next 5 y
Target payback period	5–7 y, standalone PV	10 y, PV+storage	9 y, standalone PV
Assumed PV system cost	—	$2.34/Wdc	$3.30/Wdc

Sources: Canary Media (12/15/22); CPUC Proposed Decision (11/10/22); Solar Power World (11/10/22); Utility Dive (11/11/22, 12/16/22); Wood Mackenzie and SEIA, US Solar Market Insight, Q4 2022.

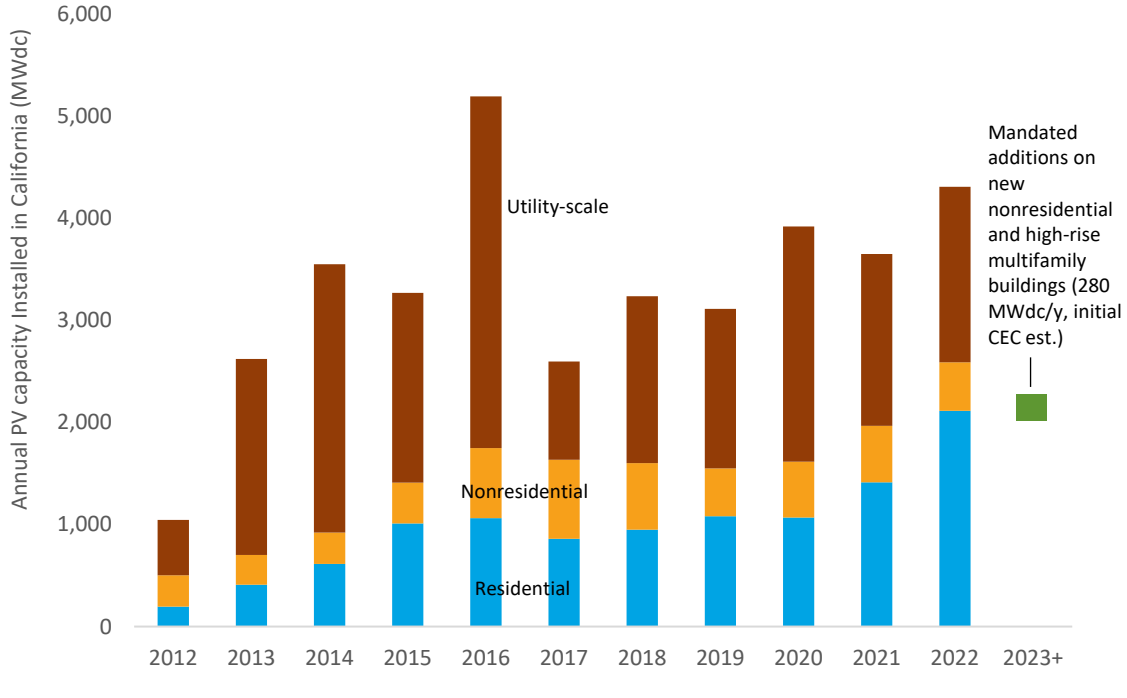
- The California Public Utilities Commission approved revised net metering rules in December 2022; they become effective April 2023.
  - The rules replace retail export rates with avoided-cost rates but omit a previously proposed grid-participation charge.
  - The aim is to mitigate cost-shifting from PV to non-PV customers, compensate PV based on its value to the grid, and—in conjunction with highly differentiated time-of-use import rates—encourage electrification and use of energy storage.
- SEIA and Wood Mackenzie project the policy will shrink California's residential PV market by 39% in 2024 after a rush to install systems under the old rules in the first part of 2023.
- Commercial PV projects are expected to contract in 2025 and 2026, as projects started under the old rules are built out in 2024.
- California accounted for about 36% of U.S. residential PV and 19% of nonresidential (excluding utility-scale) PV installed in 2022.

California Adopts Net Metering 3.0 Policy

- Many groups have been critical of the various versions of California NEM 3.0.
  - In September, a group of 129 California and national organizations wrote a letter to Governor Newsom that accused the CPUC of having “weaponized equity” in the initial California NEM 3.0 proposal.
  - Roth capital estimated California’s residential solar segment could be down 30% y/y in the 12 months after NEM 3.0 goes into effect. They also contended the changes could push California to a 100% solar+storage market, ultimately decreasing both accessibility and affordability.
  - The California Solar & Storage Association observed that given that the state is currently installing roughly 30,000 batteries and 200,000 solar systems, it could take years for storage installation rates to catch up.
  - Centrica Business Solutions estimated the plan will increase simple payback time by 2–10 years for most commercial solar customers. Wood Mackenzie estimates a 4-year increase in payback times for residential solar.
- In January, the Center for Biological Diversity, Protect Our Communities Foundation, and the Environmental Working Group together appealed CPUC’s decision on the grounds that the decision will harm the ability of environmental justice and low-income communities to benefit from solar energy.
  - The appeal states that the regulators devalued rooftop solar based on flawed modeling that ignored net metering’s benefits, including decreasing fossil fuel dependence and providing new jobs, ignored harms from fossil fuel energy)particularly to low-income communities and communities of color), and failed to analyze non-solar customer bills.

Sources: Letter from 125+ organizations to Gov Newsom re: NEM, Solar Power World, Solar.com, Solar Builder Mag, pv-mag (12/15/22, 1/19/2023), Centrica Business Solutions, Wood Mackenzie/SEIA: U.S. Solar Market Insight: Q4 2022.

California Mandates PV + Storage on Nonresidential and Multifamily Buildings



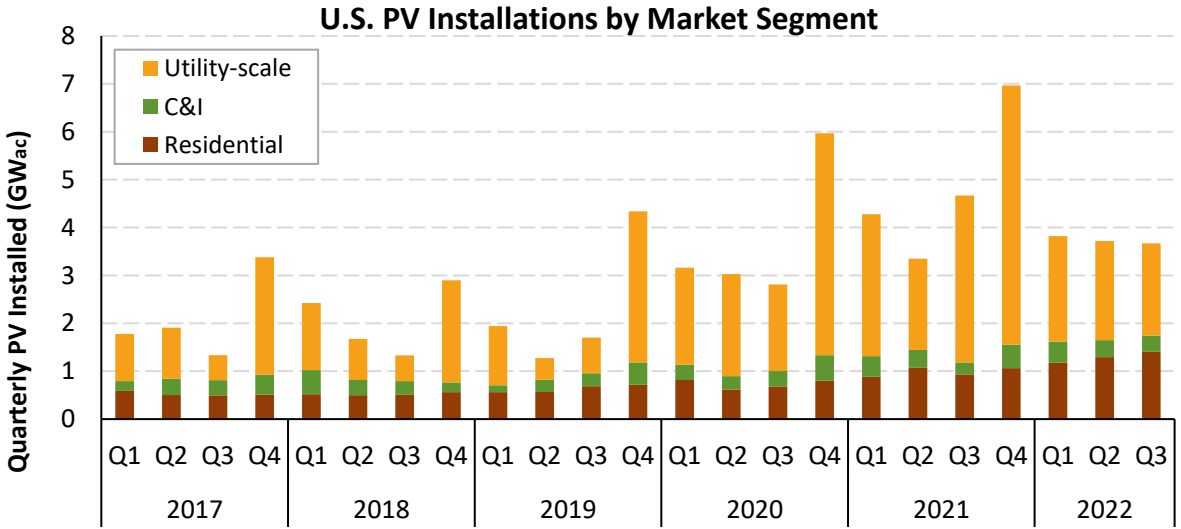
Sources: CEC, 2022 Building Energy Efficiency Standards Summary, Aug 2021; CEC, Building Energy Efficiency Standards for Residential and Nonresidential Buildings, Aug 2022; CEC, Blueprint (Jan/Mar 2022); New York Times (8/11/21); Solar Power World (8/12/21).

- On January 1, 2023, California became the first U.S. state to require PV and battery storage on newly constructed nonresidential and high-rise multifamily buildings that meet certain criteria.
  - High-rise multifamily (apartments and condos)
  - Hotel-motel, tenant space
  - Offices, medical offices, and clinics
  - Retail and grocery stores, and restaurants
  - Schools
  - Civic (e.g., theaters, auditoriums, and convention centers).
- Required PV and battery sizing is based on conditioned floor area or solar access roof area, climate zone, and building type.
- Approved community solar and battery systems may be used to meet the requirement.
- The California Energy Commission (CEC) projected (in 2021, before California's net metering policy was revised) the standards would add 280 MWdc of PV and 400 MWh of storage annually.
- California began requiring PV on new single-family homes and multifamily buildings up to three stories high in 2020.

U.S. Installation Breakdown Annual: EIA (GW_{ac})

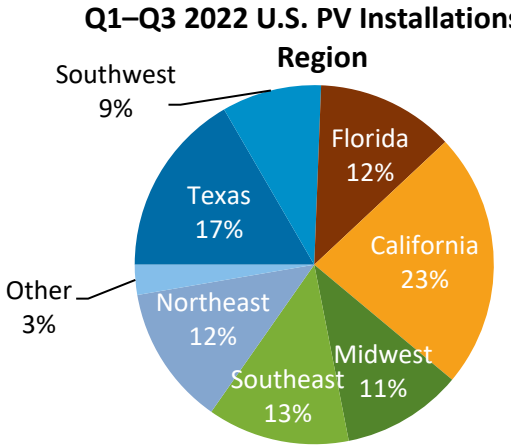
According to EIA data, the United States installed 11.2 GW_{ac} of PV in the first three quarters of 2022—down 9% from the first three quarters of 2021.

- Residential PV (3.9 GW_{ac}) was up 34% and C&I PV (1.1 GW_{ac}) was up 8% during this period.
- However, utility-scale PV (6.2 GW_{ac}) was down 26%.



Half of U.S. PV capacity installed in Q1–Q3 2022 was in California, Texas, and Florida.

- Those three states also ranked first (California), second (Texas), and third (Florida) in total installed PV as of September 2022.



Note: EIA reports values in W_{ac} which is standard for utilities. The solar industry has traditionally reported in W_{dc}.
Sources: EIA, "Electric Power Monthly," forms EIA Form 023, EIA Form 826, and EIA Form 861 (November 2022, February 2021, and February 2019).

U.S. Installation Breakdown Annual: SEIA (GW_{dc})

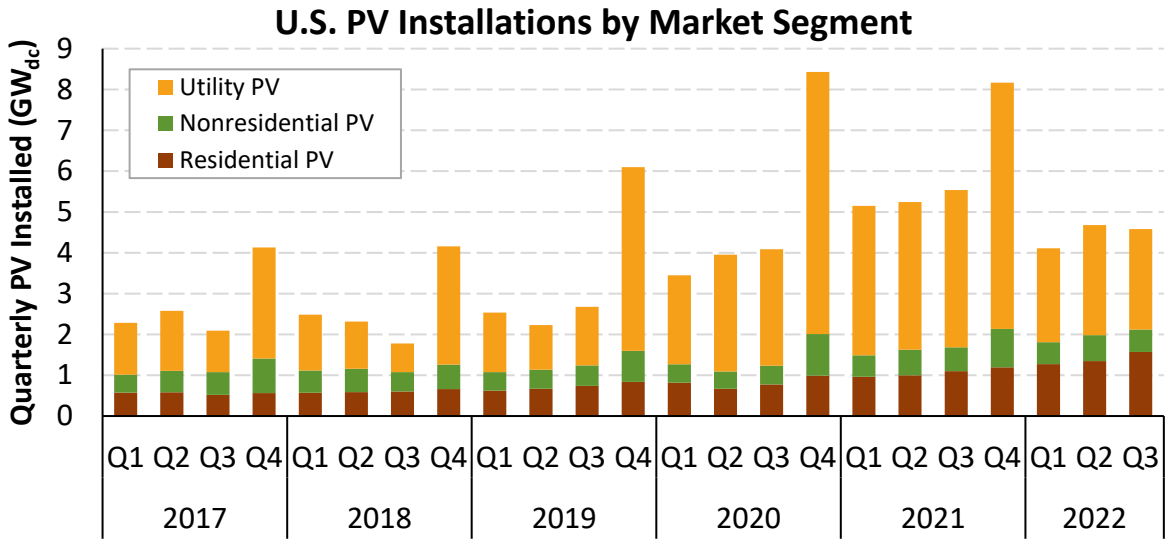
Unlike the previous slide, these values are in GW_{dc}—not GW_{ac}.

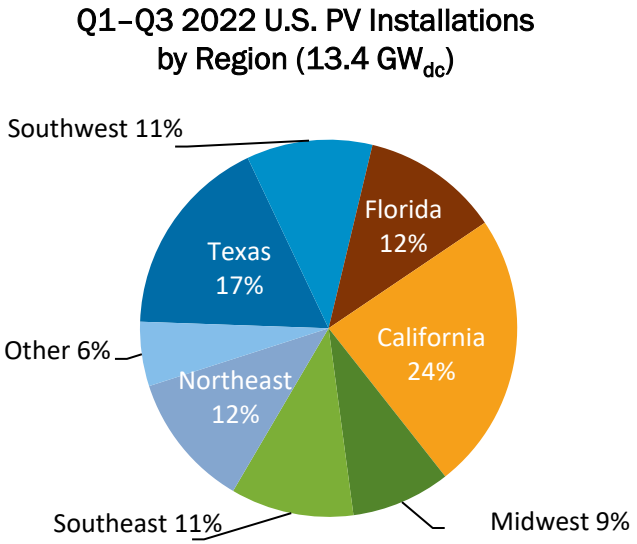
According to SEIA data, the United States installed 13.4 GW_{dc} of PV in the first three quarters of 2022—down 16% from the first three quarters of 2021.

- Residential PV (4.2 GW_{dc}) continued its strong growth and was up 37% from Q1–Q3 2021.
- However, utility-scale PV (7.5 GW_{dc}) was down 33% and C&I PV (1.7 GW_{dc}) was down 1% during this period.

Half of U.S. PV capacity installed in Q1–Q3 2022 was in California, Texas, and Florida.

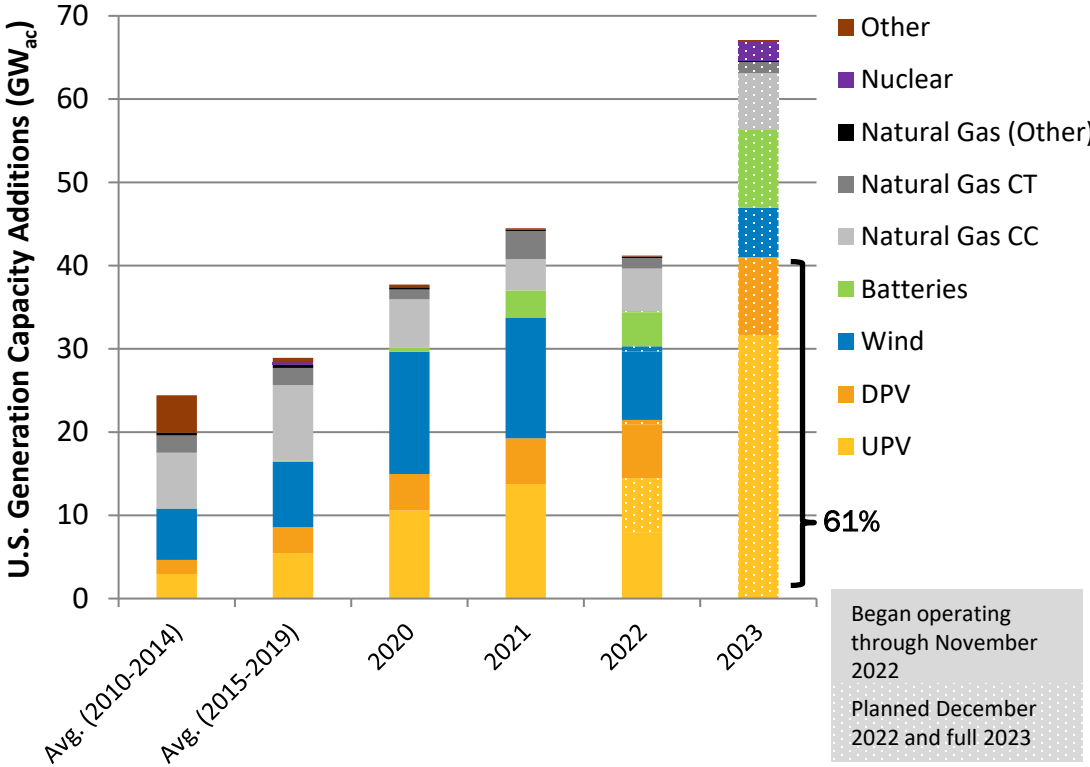
- New York continues to lead in community solar installations (55% of Q1–Q3 installs). It is followed by Maine (18%) and Massachusetts (6%).





Note: SEIA reports values in W_{dc} which is standard for the solar industry.
Sources: Wood Mackenzie/SEIA: U.S. Solar Market Insight: Q4 2022.

U.S. Generation Capacity Additions by Source: 2010–2021 and *Planned* 2022–2023

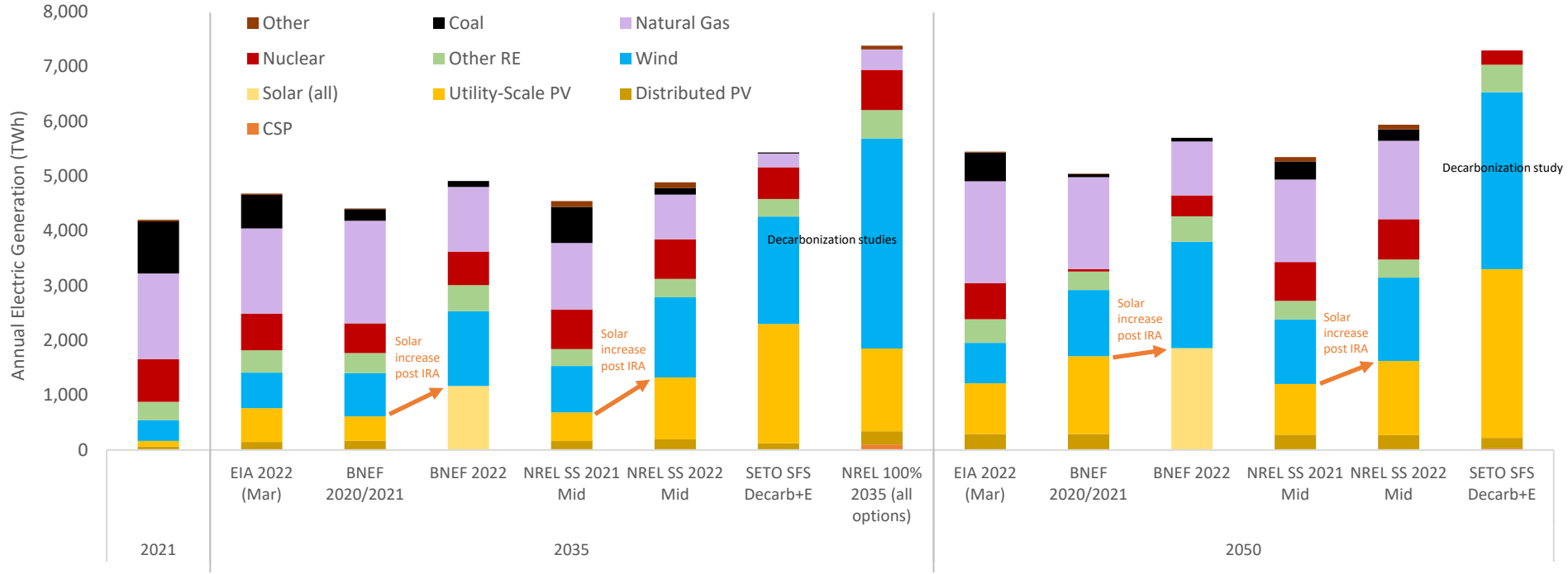


- EIA estimates the percentage of U.S. electric capacity additions from solar will grow from 43% in 2021 (19 GWac) to 52% in 2022 (21 GWac), and 61% (41 GWac) in 2023.
  - Wind accounts for 9%, batteries 15%, and nuclear 3% of estimated capacity in 2023.
  - Natural gas accounts for the remaining 10% in 2023.
- EIA's January 2023 estimate for PV capacity additions in 2023 (41 GWac) is 8 GWac (24%) higher than EIA's August 2022 estimate, which was made immediately before passage of the IRA.
- Wood Mackenzie and SEIA also increased their 2023 PV deployment estimate after passage of the IRA, but their December estimates are only about half of the EIA estimate for 2023 because of ongoing supply chain constraints.
  - Owing to those constraints, Wood Mackenzie and SEIA expect the full benefits of the IRA will only be realized in 2024 or later.

Sources: EIA Form 860M/Preliminary Monthly Electric Generator Inventory ("Planned" and "Operating" Nov 2022); EIA Short-term Energy Outlook Table 8b, Jan 2023; Wood Mackenzie and SEIA, Q4 2022 US Solar Market Insight, Sept 2022.

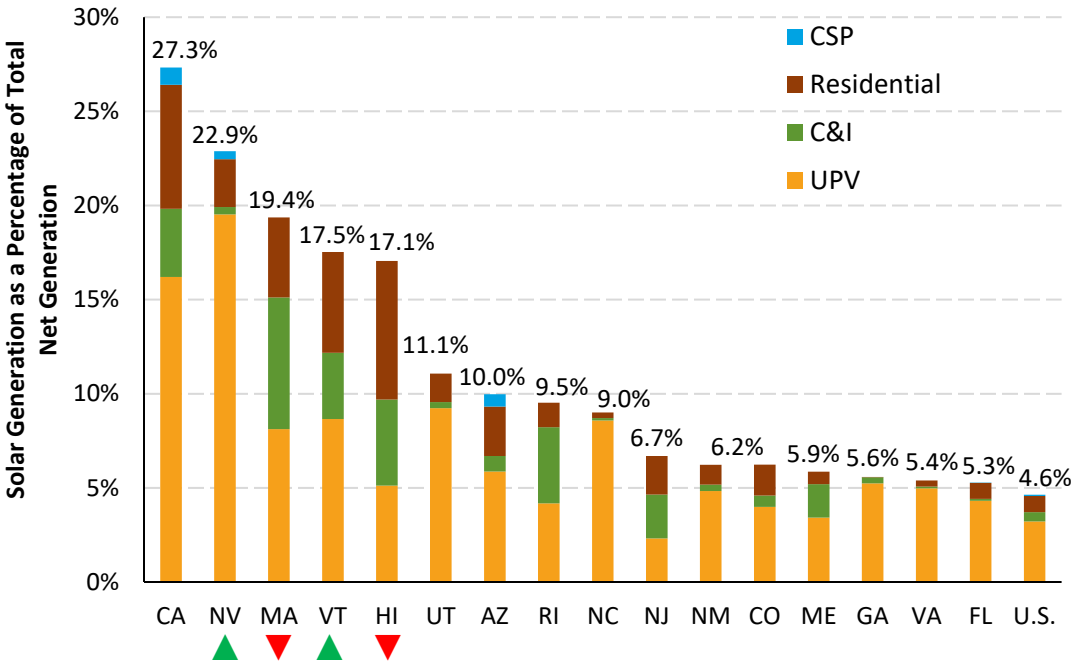
U.S. Solar Projections Increase After IRA Passage

- BloombergNEF and NREL U.S. solar generation projections after IRA passage increased by 90%–93% for 2035 and 9%–35% for 2050.
- Solar generation in these newer projections comes closer to DOE decarbonization projections, but solar generation would still need to increase 40%–100% to reach those decarbonization projections.



Sources: BloombergNEF, New Energy Outlook 2020, 2021, 2022; EIA, Annual Energy Outlook 2022; NREL, 2021 Standard Scenarios; NREL, 2022 Standard Scenarios; NREL, Examining Supply-Side Options to Achieve 100% Clean Electricity by 2035; DOE SETO, Solar Futures Study.

Solar Generation as a Percentage of Total Generation, Q4 2021–Q3 2022



Note: EIA monthly data for 2022 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 distributed PV 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 January 23, 2023.

- During the 1-year time span from Q4 2021 to Q3 2022, 17 states generated more than 5% of their electricity from solar, with California leading the way at 27.3%.
  - Five states (California, Nevada, Massachusetts, Vermont, and Hawaii) generated more than 15% of their electricity using solar.
  - These five states have consistently led in solar generation for several years, although Nevada overtook Massachusetts and Vermont overtook Hawaii during this period.
  - Colorado, Maine, Georgia, Virginia, and Florida all recently surpassed 5% solar generation. Interestingly, despite having significant levels of deployment, Texas, at 4.7%, has yet to hit this threshold.
- Nationally, 4.6% of electricity was generated from solar—up from 3.9% during calendar year 2021.
- The roles of utility and distributed solar varies by state. Southern and Western states rely more on utility-scale solar, while northern states and Hawaii rely more on distributed solar.

U.S. Energy Storage Installations by Market Segment (Energy Storage Association)

The United States installed approximately 11.1 GWh (3.7 GW_{ac}) of energy storage onto the electric grid in Q1–Q3 2022, +88% (+90%) y/y as a result of high levels of residential deployment and grid-scale deployment.

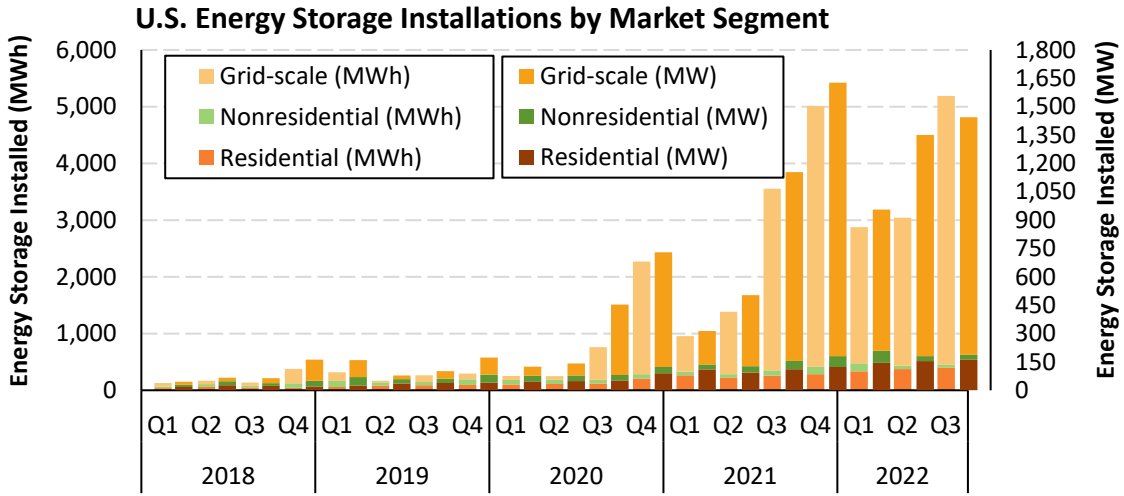
- Grid-scale and residential storage installations were up 48% (26%) and 55% (44%) in Q2 2022 y/y respectively.
- Nonresidential storage had another lackluster quarter, installing only 26.6 MW_{ac}.

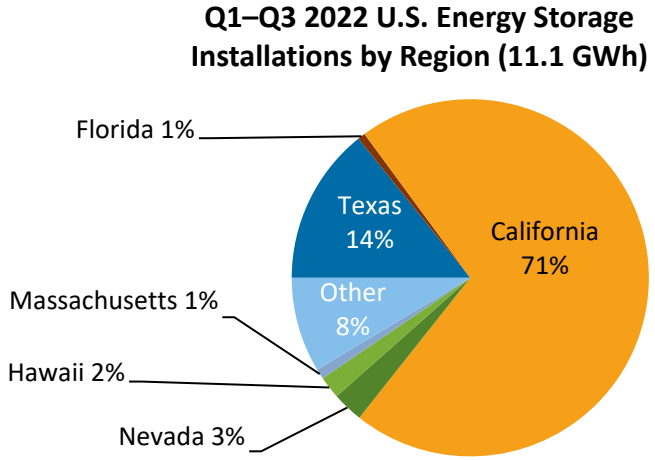
Wood Mackenzie's total outlook for 2022–2026 across all segments yielded an average upgrade of 108% compared to the Q3 forecast.

- This was driven by new grid-scale project announcements and increased residential and nonresidential volumes in California due to the introduction of a community solar program and NEM 3.0.

California again took the lead in all three categories in Q3 2022, installing nearly 20× more grid-scale capacity than the next nearest state (Texas).

- Puerto Rico, Arizona, and Texas also had record-breaking quarters for residential deployment.





Note: Front-of-the-meter refers to all projects deployed on the utility side of the meter, regardless of size or ownership.

Source: Wood Mackenzie Power & Renewables and Energy Storage Association, U.S. Energy Storage Monitor: Q4 2022.

U.S. Energy Storage Installations by Market Segment (EIA)

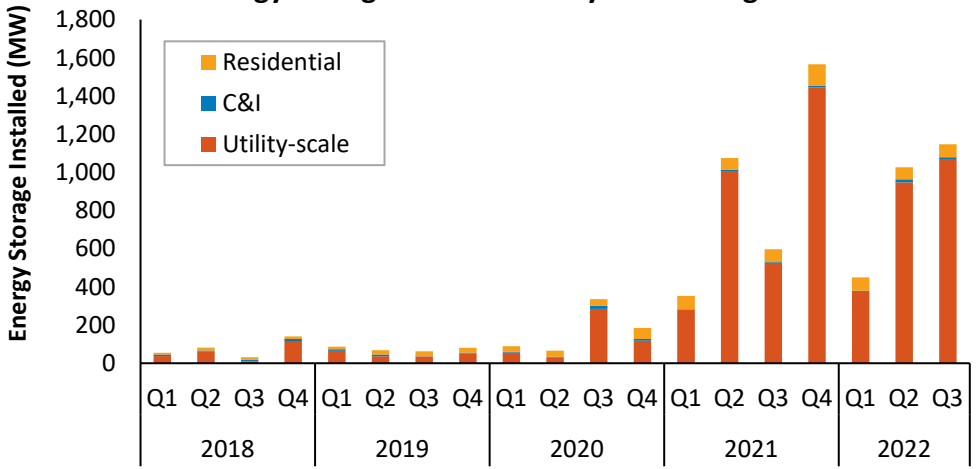
The United States installed approximately 2.8 GW_{ac} of energy storage onto the electric grid in the first 9 months of 2022— up 28% y/y as a result of high levels of utility-scale and C&I deployment.

– Q3 2022 installations increased 88%, y/y.

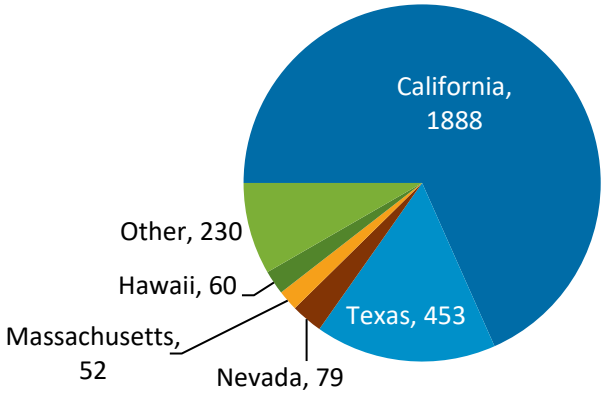
California represented approximately two-thirds of installed battery storage capacity, followed by Texas (16%).

– The top five markets represented 92% of installed energy storage capacity.

U.S. Energy Storage Installations by Market Segment

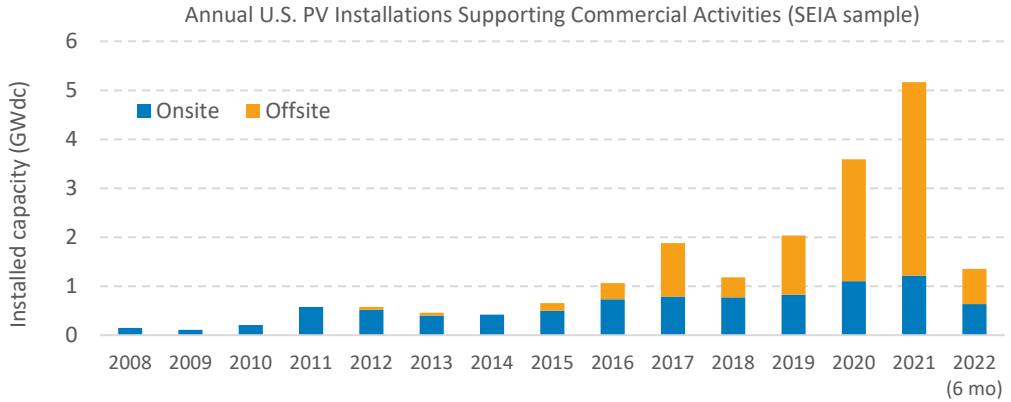


Q1–Q3 2022 U.S. Energy Storage Installations by Region (2.8 GW)

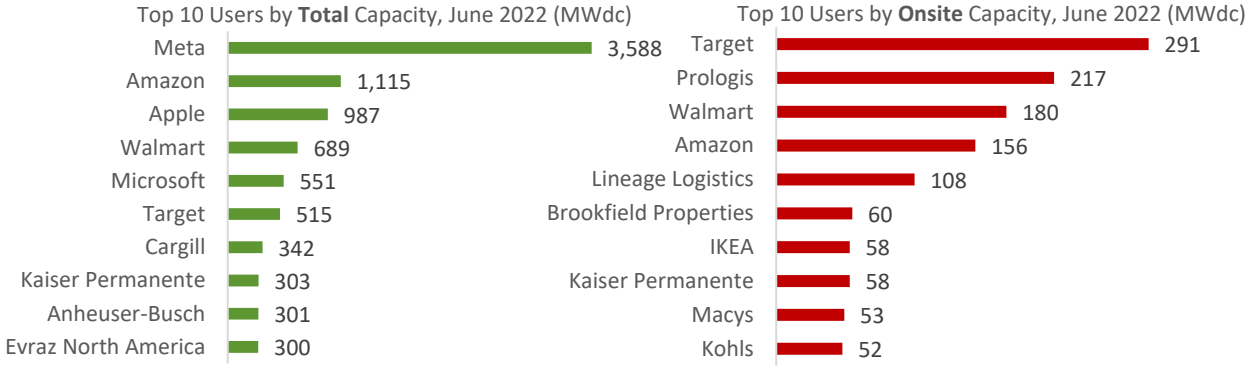


Sources: EIA Form 860M, EIA Form 861M.

PV Increasingly Supports U.S. Commercial Activities



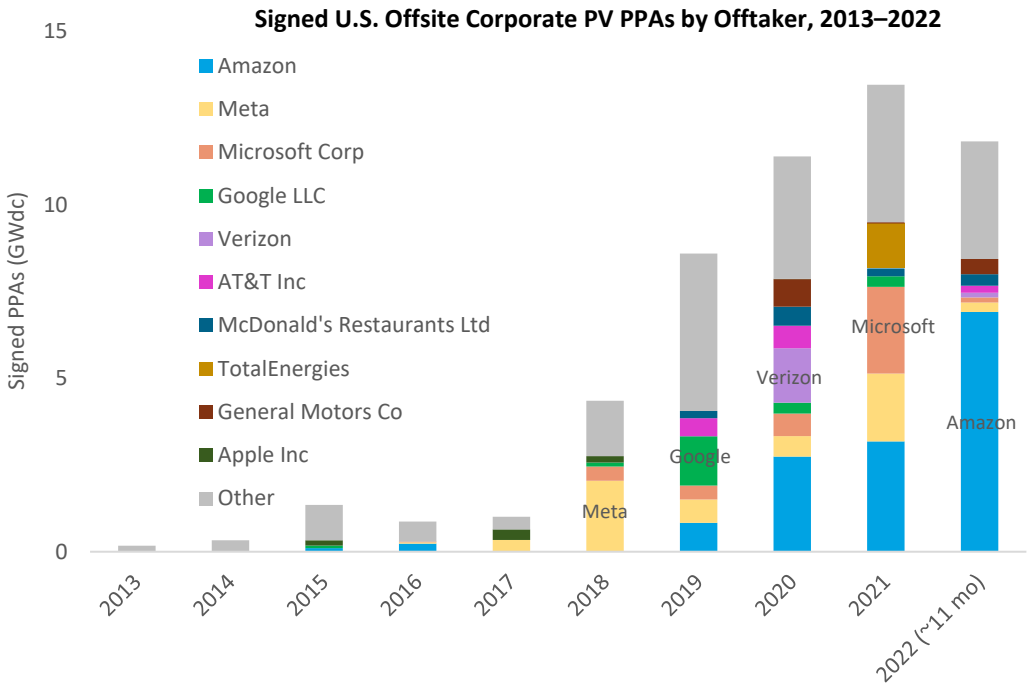
- The Solar Energy Industries Association (SEIA) reports that PV projects supporting commercial activities at U.S. facilities grew rapidly between 2018 and 2021 mostly due to offsite systems; annual offsite additions doubled every year and constituted two-thirds of the total sample during this period.
- Almost one-quarter of all utility-scale projects in 2021 included one or more commercial buyers.
- The pace of growth slowed in 2022 because of PV supply chain and trade issues.



- Meta accounts for the most total installed capacity through June 2022, at 3.6 GWdc.
  - This is equivalent to 3% of all U.S. PV.
  - About 80% installed after 2019.
- Tech companies, with their large data-center energy use, hold four of the five top total PV spots.
- Retail and real estate companies dominate onsite PV; three-quarters of the capacity is roof-mounted.
- Of the top 25 total PV leaders ranked in SEIA's report, 18 are pursuing 100% renewable energy or carbon-neutral goals.

Source: SEIA, Solar Means Business, 2022.

Signed Offsite Corporate PPAs Create Large U.S. PV Pipeline



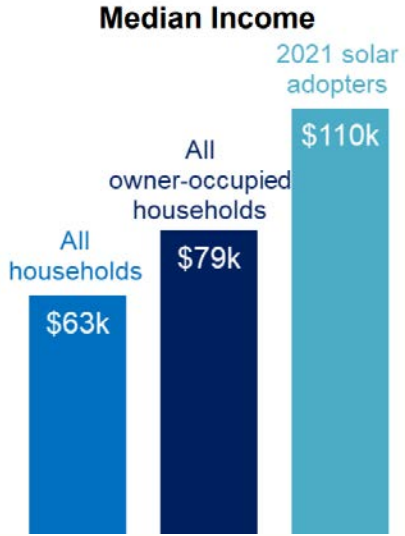
- Offsite corporate PPAs signed in the past several years eclipse all PV currently installed to support U.S. commercial activities.
  - The annual growth of signed PPAs almost doubled each year between 2017 and 2021. Annual signed capacity reached 13.4 GWdc in 2021.
  - Completion of all projects signed in 2018 through most of 2022 would represent 50 GWdc of PV capacity (compared with 26 GWdc installed by June 2022, according to SEIA)
  - For context, all nonresidential and utility-scale PV installed in the United States at the end of 2022 totaled 110 GWdc.
- Comparing BloombergNEF signed-PPA data and SEIA installed-system data indicate the lag between PPA signing and system installation.
  - For example, SEIA reports Amazon's installed capacity at 1.1 GWdc as of June 2022, but during 2020 through most of 2022, Amazon signed PPAs equivalent to an additional 12.8 GWdc.
  - PPAs signed by Meta, Microsoft, and Verizon during this period account for another 7.8 GWdc.

Sources: `, "Corporate PPA Deal Tracker," December 2022; SEIA, Solar Means Business, 2022; Wood Mackenzie/SEIA, U.S. Solar Market Insight: Q4 2022, December 2022.

LBNL's ~Annual Residential Solar-Adopter Trends Report

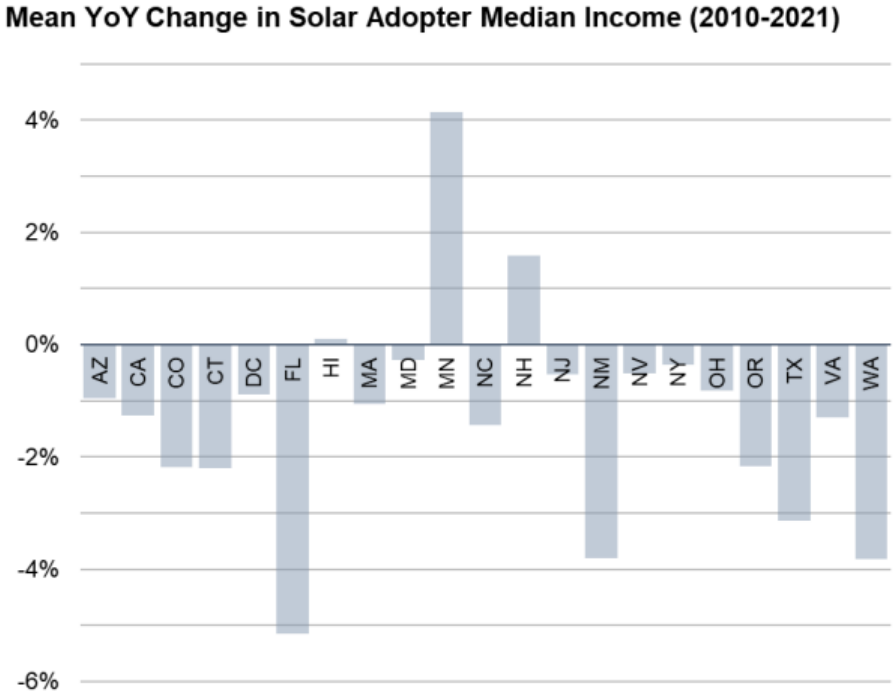
Sydney Forrester, Galen Barbose, Eric O'Shaughnessy, Naïm Darghouth, and Cristina Crespo Montañés. 2022. *Residential Solar-Adopter Income and Demographic Trends: November 2022 Update*. Lawrence Berkeley National Laboratory. https://eta-publications.lbl.gov/sites/default/files/solar-adopter_income_trends_nov_2022.pdf

LBNL recently published its *Residential Solar-Adopter Income and Demographic Trends: November 2022 Update*.



Source: Forrester et al. 2022

Low- and Moderate-Income Adoption
While solar adoption skews toward high-income households, low- and moderate-income households are also adopting. In 2021, about 43% of adopters earned less than 120% of their area's median income. (120% is a threshold sometimes used to include both low and moderate income)

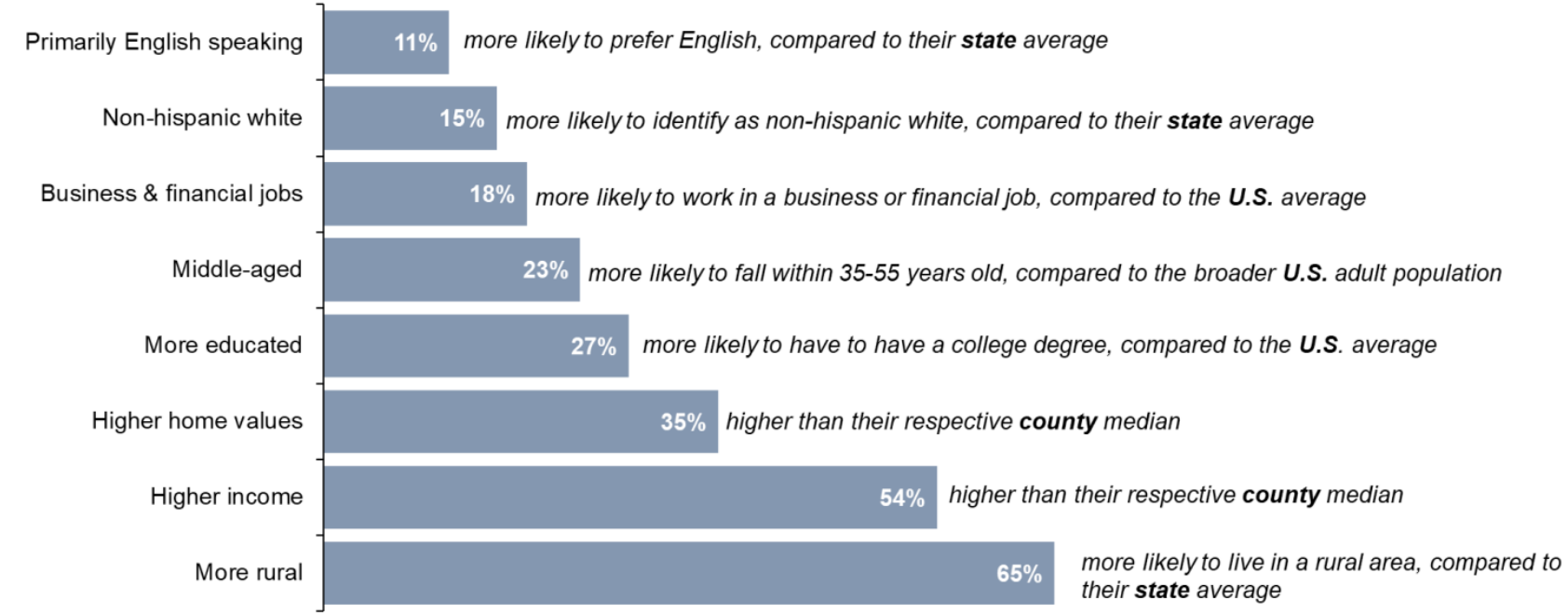


Most states show declining solar-adopter incomes over time, with generally an average drop of 1%–2% per year over the 2010–2021 period.

LBNL's ~Annual Residential Solar-Adopter Trends Report

Source: Forrester et al. 2022

Compared to the General Population, 2021 Solar Adopters Tend to Have or Be...

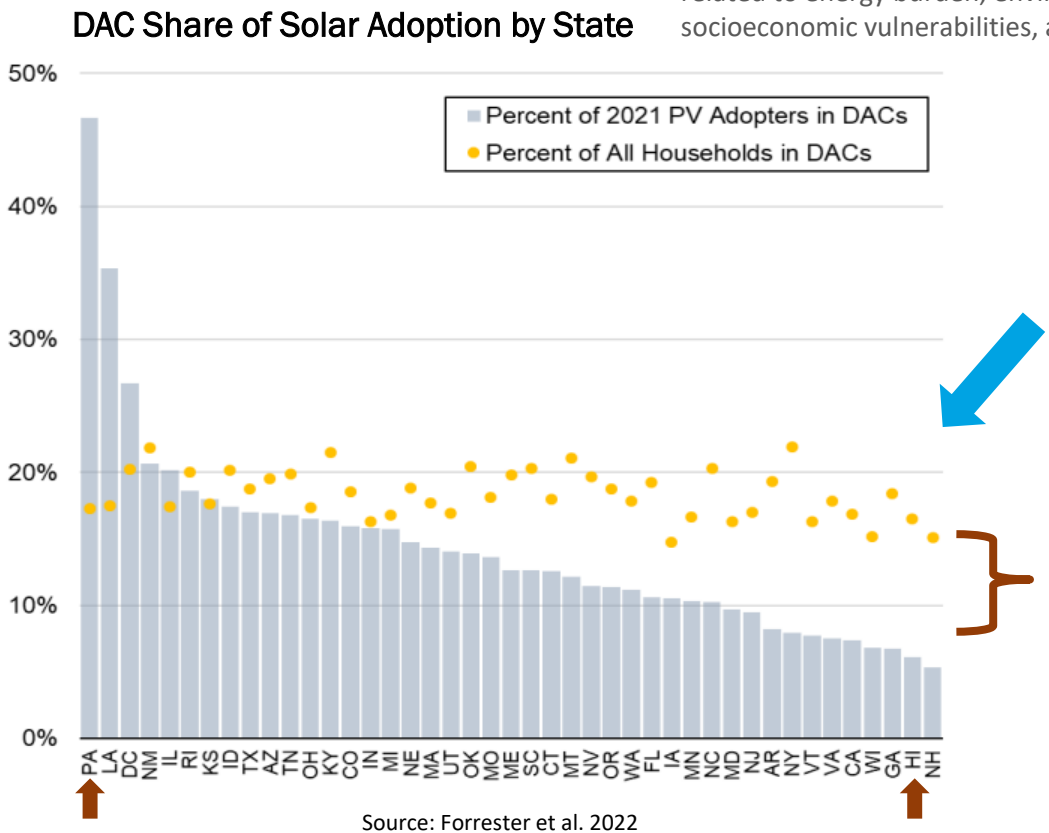


These skews all generally trend closer to national averages, with the notable exceptions being Black (non-Hispanic) households, which remain steadily underrepresented and rural households which are consistently overrepresented during the past several years.

LBNL's ~Annual Residential Solar-Adopter Trends Report

DAC = disadvantaged communities, a DOE term based on 36 criteria related to energy burden, environmental and climate hazards, socioeconomic vulnerabilities, and fossil-based fuel dependence.

The percentage of PV adopters in DACs varies widely, from 6% (Hawaii) to 46% (Pennsylvania), though it is typically less than 20%



Source: Forrester et al. 2022

Percentage of all households in DACs is fairly uniform across states

In most states, DACs are underrepresented among PV adopters relative to their share of all households in the state

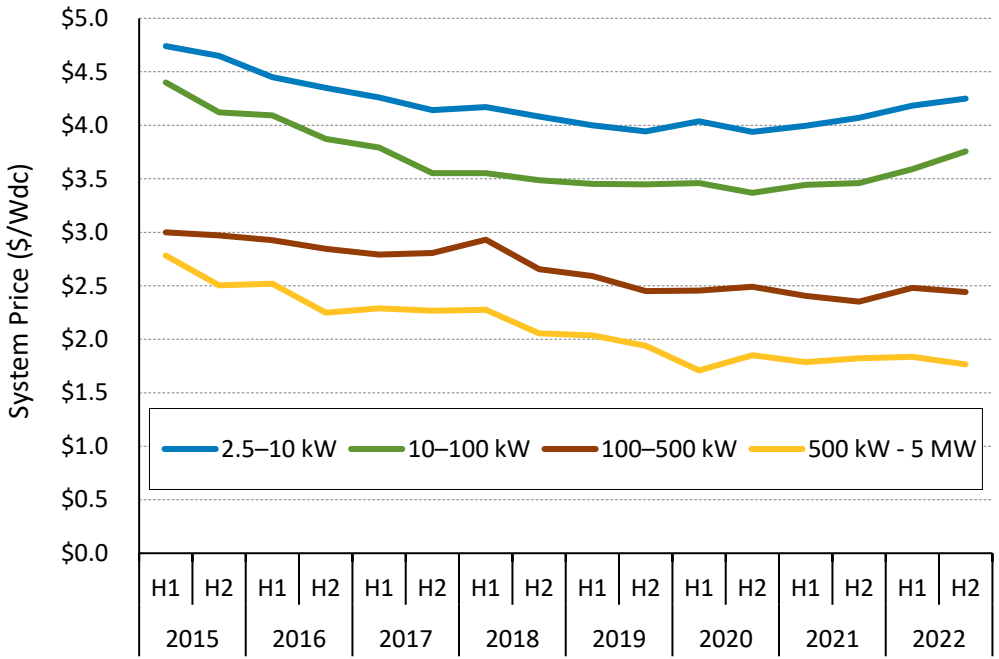
Agenda

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

From H2 2021 to H2 2022 (partial), the median reported distributed PV system price in Arizona, California, Massachusetts, and New York:

- Increased 4% to $4.25/Wdc for systems 2.5 to 10 kW
- Increased 9% to $3.76/Wdc for systems 10 to 100 kW
- Increased 4% to $2.44/Wdc for systems 100 to 500 kW
- Decreased 3% to $1.77/Wdc for systems 500 kW to 5 MW.

Distributed PV System Pricing from Select States



2022 MW reported YTD: Arizona (186), California (1,232), Massachusetts (108), New York (711)
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 the data set to show a trend over time.
Sources: Arizona Goes Solar (1/17/23); California Distributed Generation (11/30/22); Massachusetts Lists of Qualified Generation Units (1/11/23); Solar Electric Programs Reported by NYSERDA (1/19/23); Wood Mackenzie & SEIA, US Solar Market Insight: Q4 2022 (12/22).

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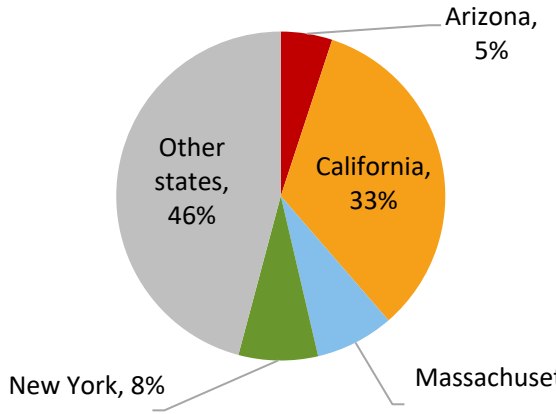
  - Increased 4% to $2.44/Wdc for systems 100 to 500 kW
  - Decreased 3% to $1.77/Wdc for systems 500 kW to 5 MW.
- These states constituted 54% of U.S. distributed PV deployment over the past 10 years.

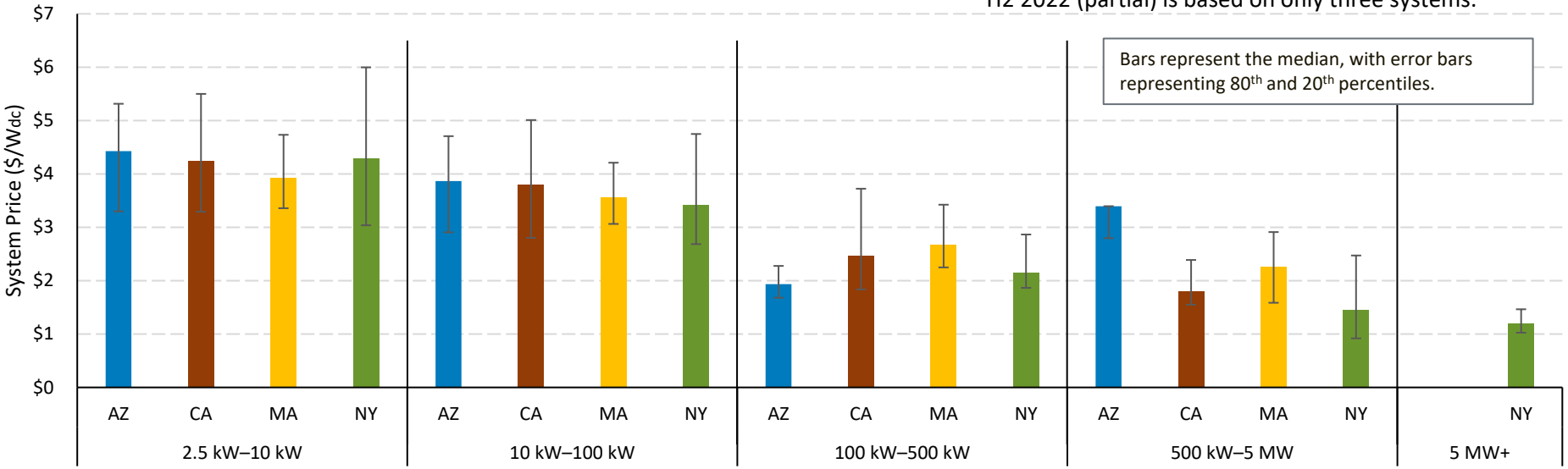
U.S. Distributed PV Deployment Over 10 y



Distributed System Pricing from Select States, H2 2022 (partial)

- In addition to price differences based on system size, there is variation between states and within individual markets.
- Dollar-per-watt prices generally decrease as system size increases.

- For systems of less than 100 kW, price increases varied between H2 2021 and H2 2022 (partial):
  - 5%–8% in Arizona, 3%–9% in California, 3%–10% in Massachusetts, 8%–11% in New York
- Price changes in systems greater than 100 kW varied dramatically in some states during this period because of small system sizes.
  - For example, the 500 kW–5 MW price in Arizona in H2 2022 (partial) is based on only three systems.



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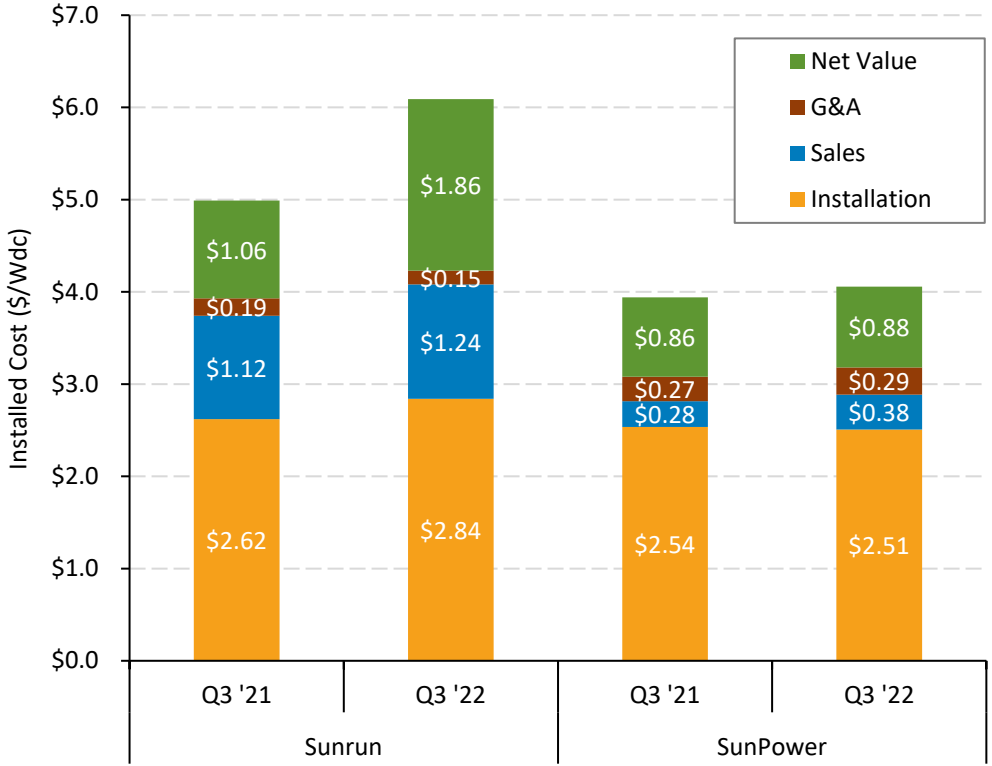
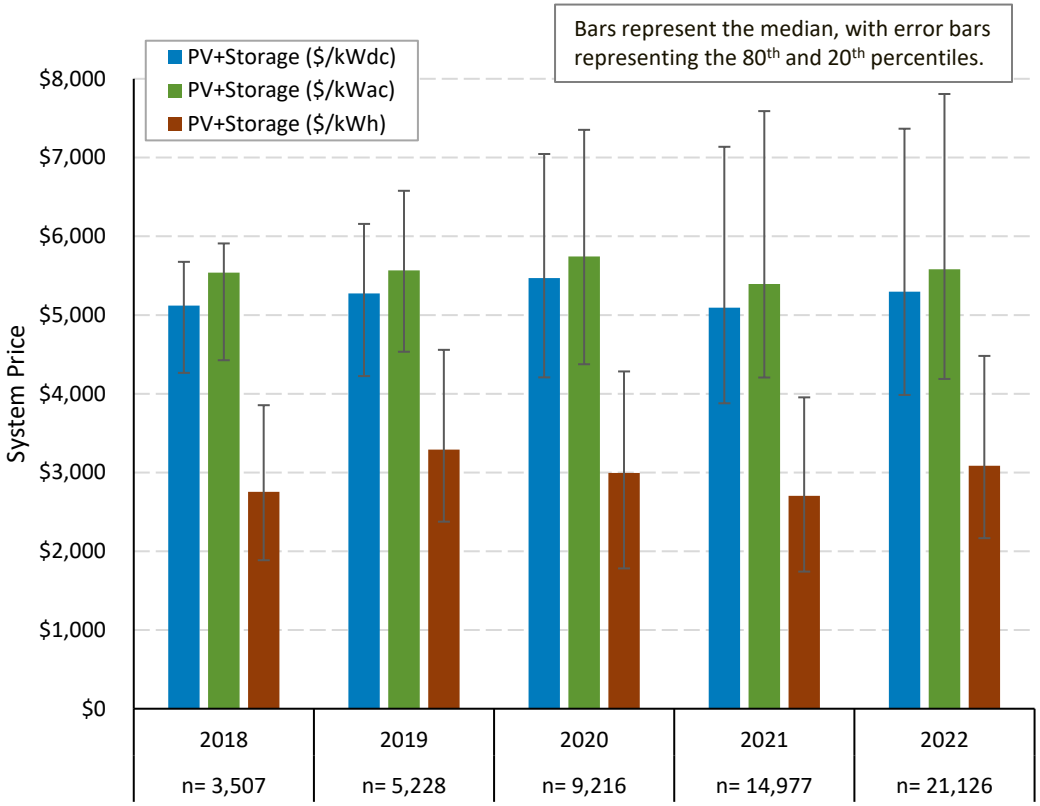
Sunrun and SunPower Cost and Value, Q3 2022



- Large residential installers reported strong demand for PV in Q3 2022, and they experienced supply issues as inflationary pressures rather than barriers to timely installation.
  - Customer additions increased 20%–60% y/y for Sunrun, Sunnova, and SunPower, and large customer backlogs were reported (e.g., 54,000 customers for SunPower).
  - Installers said the high cost and low reliability of residential utility service boosted PV demand and allowed higher PV prices.
  - Electric vehicle purchases are also driving residential PV demand, and some installers are partnering with automakers.
  - Enforcement of the Uyghur Forced Labor Prevention Act continued to delay module imports, but overall, module availability enabled timely project completion.
- Costs include PV systems paired with batteries.
  - Battery attachment rates for Sunrun, Sunnova, and SunPower were 14%–30% in Q3 2022.
  - Sunrun said battery supply constraints hampered growth, while Sunnova reported substantially increased battery supply.

Sources: Corporate filings.

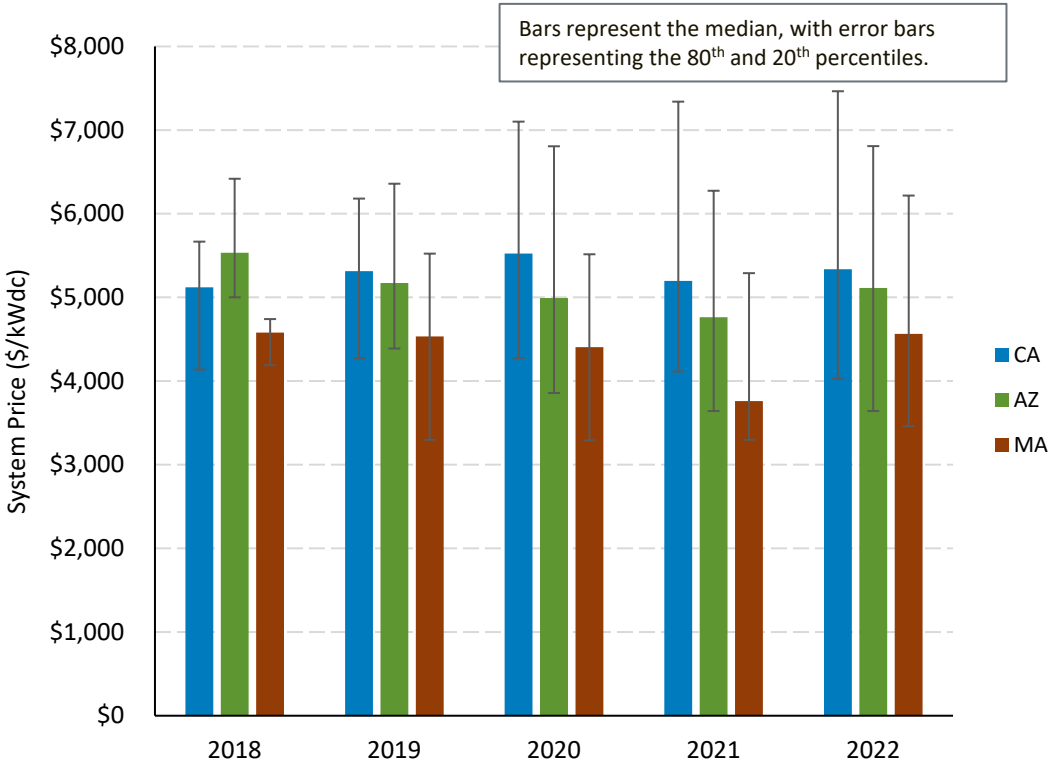
Residential U.S. PV+Storage Pricing



- In 2022 YTD, residential PV+storage systems in Arizona, California, and Massachusetts had a median system price of $3,100/kWh, or $5,600/kWac ($5,300/kWdc)—an increase of 3%–14% compared with full 2021 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).

2022 YTD residential PV+storage sample, after data cleaning (MW): Arizona (13), California (179), Massachusetts (9)
Sources: Arizona Goes Solar (1/17/23); California Distributed Generation (11/30/22); Massachusetts Lists of Qualified Generation Units (1/11/23).

Residential U.S. PV+Storage Pricing



- In 2022 YTD, 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.
- Compared with full median 2021 values, prices (in dollars per kWdc of PV capacity) increased in 2022 YTD in Arizona (7%), California (3%), and Massachusetts (21%).

2022 YTD residential PV+storage sample, after data cleaning (MW): Arizona (13), California (179), Massachusetts (9)
Sources: Arizona Goes Solar (1/17/23); California Distributed Generation (11/30/22); Massachusetts Lists of Qualified Generation Units (1/11/23).

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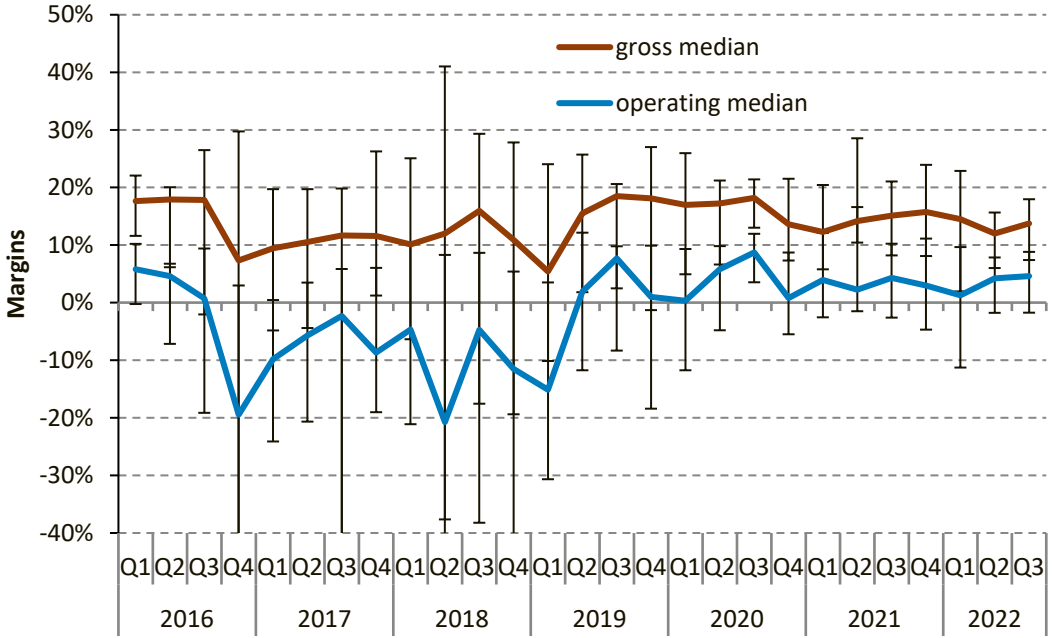
7. U.S. PV Imports

- **In H1 2022, U.S. c-Si module production was at approximately the same level as in H1 2019, while thin-film (i.e., CdTe) production has grown by 3X (and increasing 31%, y/y).**
- **Since the IRA's passage, over 85 GW of manufacturing capacity has been announced across the solar supply chain, including 19 separate new manufacturing plants.**
- **In December, the U.S. Department of Commerce issued a preliminary decision to impose anti-circumvention duties on some solar panels and cells produced in Vietnam, Malaysia, Thailand, and Cambodia. A final determination is due May 1, 2022.**
- **Several leading global PV companies announced expansion corporate production capacity to 50 GW or greater by 2023.**

PV Manufacturers' Margins



- PV manufacturers, mostly Chinese companies, have generally been profitable since 2019.
- Since 2021, the median gross margin of the publicly traded PV companies represented to the left has been 12%–16% and the median operating margin has been 1%–5%.
- There continues to be significant variation by individual companies as individual factors come into play, although variation has been substantially less since 2019.
- Companies continue to expand manufacturing, with Tongwei, LONGi, JinkoSolar, and Canadian Solar having reached, or reaching, 50 GW – 100 GW of wafer, cell, and module manufacturing, each in 2022 and 2023.

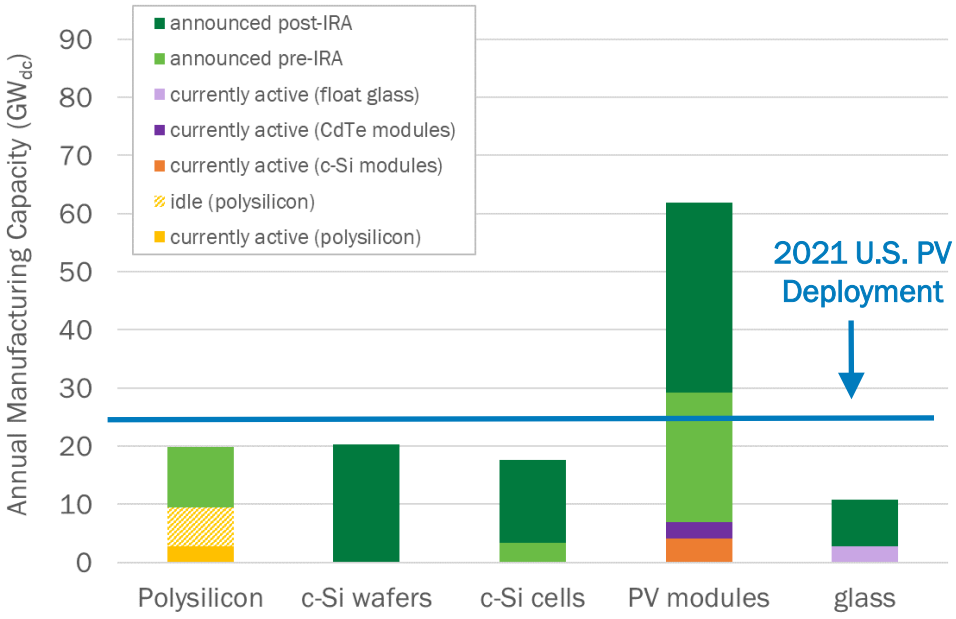
Lines represent the median, with error bars representing 80th and 20th percentiles for the following companies in Q1 2022: Canadian Solar, First Solar, JA Solar, Jinko Solar, LONGi, Maxeon, Motech Industries, REC Silicon, Renesola, Risen, Shanghai Aiko, Shanghai Aerospace, Tongwei, Trina Solar, and United Renewable Energy. Margin data from Hanwha Q Cells, Sunpower, and Yingli are also included from Q1 2010 to Q1 2022 where available.

Note: Gross margin = revenue – cost of goods sold (i.e., the money a company retains after incurring the direct costs associated with producing the goods or services it sells); operating margin = gross margin minus overhead and operating expenses (i.e., the money a company retains before taxes and financing expenses).

Sources: Company figures based on public filings and finance.yahoo.com; PVTech (10/11/22).

Domestic Manufacturing Announcements

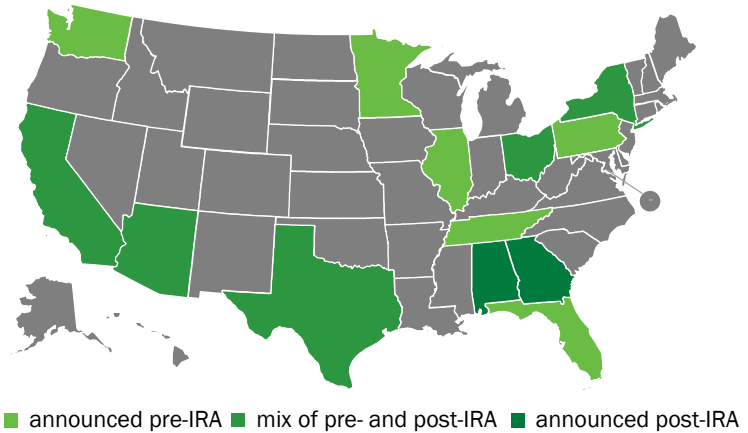
Since the IRA's passage, over 85 GW* of manufacturing capacity has been announced across the solar supply chain, including 18 separate new manufacturing plants.



Significant wafer and cell capacity has been announced over the past 3 months, although the announced capacity is still below what would be needed to meet even 2021 deployment via a fully domestic supply chain.

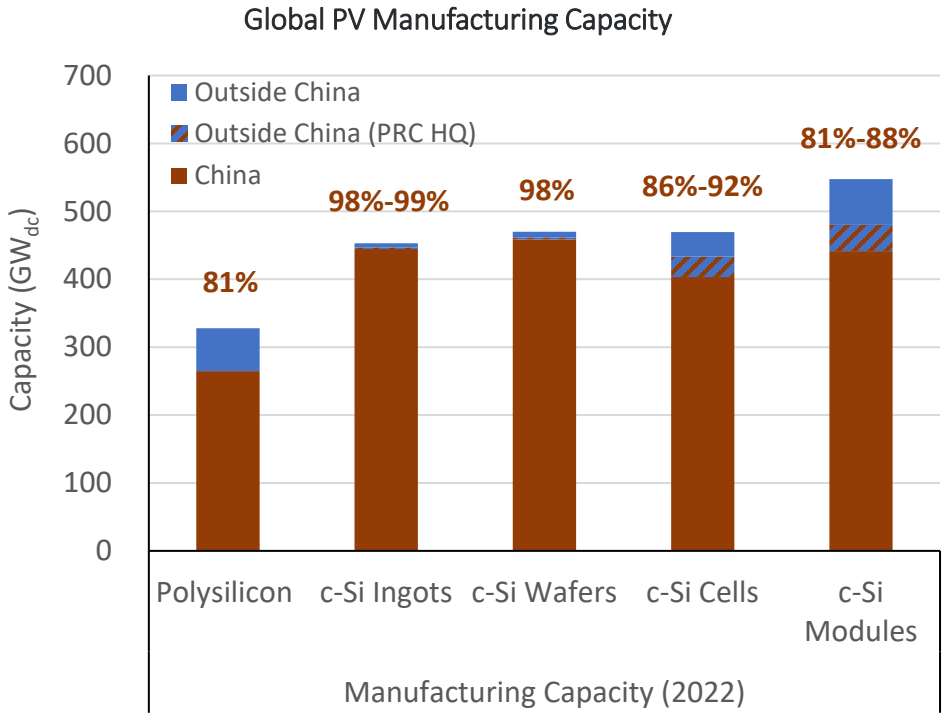
- Notable announcements in Q4 of 2022 included a:
  - 3.3-GW vertical wafer/cell/module facility from Qcells,
  - 6-GW vertical cell/module facility from Enel
  - 10-GW wafer facility from CubicPV.

These announcements pre- and post-IRA represent potential investment in at least 13 states with most slated to begin operation within the next 2 years.

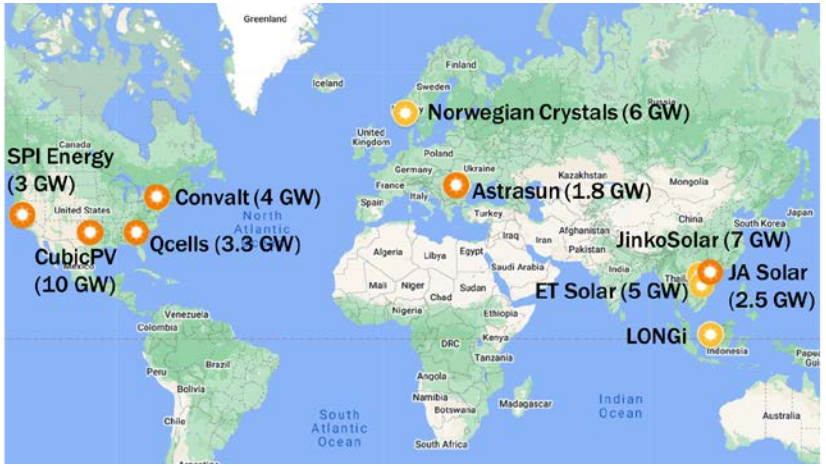


Sources: the U.S. International Trade Commission DataWeb, Wood Mackenzie/SEIA: U.S. Solar Market Insight: Q2 2022, and compilation of public announcements (see Appendix). *In addition to new PV module, c-Si cell, and wafer manufacturing, there is also 6 GW of tracker and 8 GW of inverter manufacturing not graphed.

The Global PV Ecosystem

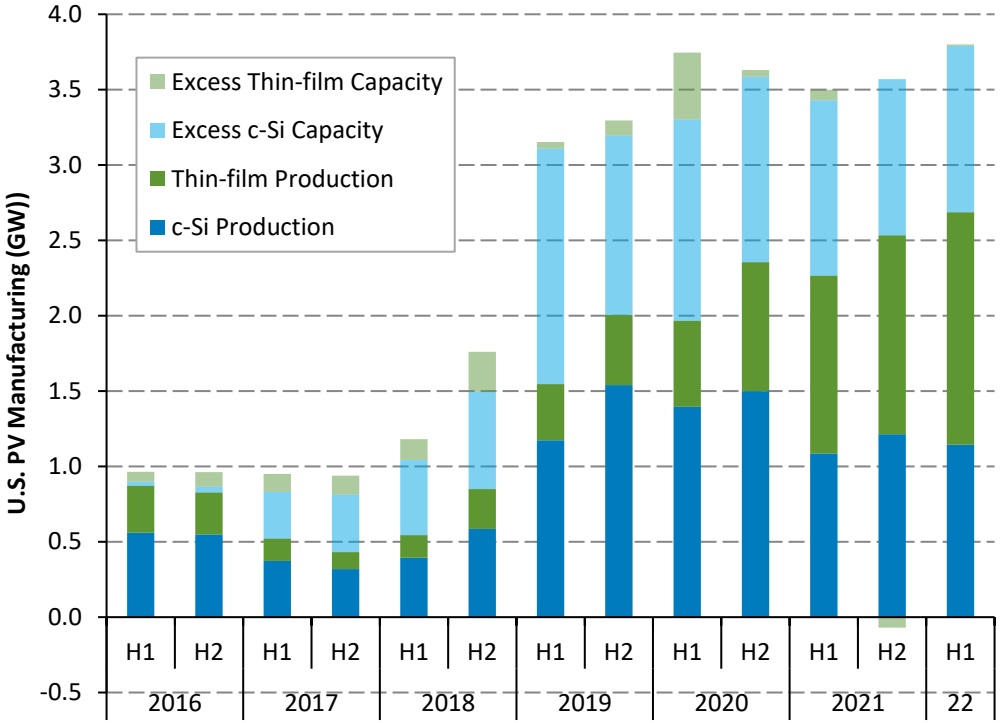


- As of December 2022, over 80% of each of the various c-Si manufacturing steps is performed in China. Ingot and wafer form the tightest bottleneck, at 98% of global capacity within China.
  - The percentages rise even higher when accounting for manufacturing facilities located outside China but headquartered within China.
  - Given the announced capacity increases within China, this imbalance is unlikely to change soon.
- However, there have been several recent announcements of wafer/ingot capacity around the globe outside China.



Sources: BloombergNEF, as of December 2022. Ultra Low-Carbon Solar Alliance, Convalt, ET Solar, JA Solar, Norwegian Crystals, Astrasun, and LONGi.

U.S. Module Manufacturing



- In H1 2022, U.S. c-Si module production was at approximately the same level as in H1 2019. Meanwhile thin-film (i.e., CdTe) production has grown by 3X (and increased 31%, y/y).
  - In H1 2022, c-Si and thin-film manufacturing had utilization rates of 51% and 99% respectively.
  - Since H1 2021, the U.S. has produced more CdTe modules than c-Si modules, despite having a lower manufacturing capacity.
- Manufacturing incentives for the IRA were not available in 2022, and guidance has still not been released on many provisions. It may take some time to see an impact on domestic production.

Source: Wood Mackenzie Power and Renewables/SEIA: U.S. Solar Market Insight Q2 2022 and previous U.S. Solar Market Insight reports.

Recent Solar News (Trade)

Country	Determination	Company Investigated[a]	Determination
Malaysia	Circumventing	Hanwha Qcells	Not
		JinkoSolar	Not
Vietnam	Circumventing	Boviet	Not
		Vina Solar	Circumventing
Thailand	Circumventing	Canadian Solar	Circumventing
		Trina	Circumventing
Cambodia	Circumventing	BYD Hong Kong	Circumventing
		New East Solar	Not

[a] 22 companies that did not respond to Commerce's request for information were declared in violation by default

In December, the U.S. Department of Commerce issued a preliminary decision to impose anti-circumvention duties on some solar panels and cells produced in Vietnam, Malaysia, Thailand, and Cambodia. A final determination is due May 1, 2023.

- Imported Southeast Asian panels will be treated as Chinese if they are made from wafers produced in China and have more than two other components produced in China. The other components are silver paste, aluminum frames, glass, backsheet, ethylene vinyl acetate sheets, and junction boxes.
- Southeast Asian cells, even if made from wafers from China, that are then exported to a non-inquiry country and further assembled into modules or other products there, are not subject to Commerce's preliminary circumvention findings.
- If companies already have a set duty in place for Chinese AD/CVD that will be used; if not, China-wide rates of 238.95% (AD) and 12.34% (CVD) will be used.

- In early November, it was reported that the U.S. CBP had blocked more than 1,000 shipments of PV modules due to the enforcement of the Uyghur Forced Labor Prevention Act. Roth Capital estimated that as much as 9 GW – 12 GW of PV panels could be prevented from entering U.S. market in 2022.
- In late November, Roth Capital reported a "meaningful supply" of solar panels had been released to the U.S. market (JinkoSolar modules made with Wacker polysilicon).

Sources Department of Commerce Press Release, Wood Mackenzie/SEIA Brace for impact! report, Reuters.

European Push for IRA-Like Incentives

Wacker, Meyer Burger, NorSun, Norwegian Crystals, ECM Group, Fraunhofer ISE and Fraunhofer Center for Silicon Photovoltaics CSP issued a joint statement on January 11 as key stakeholders from the European solar PV community to demand urgent political action to revitalize a sustainable PV manufacturing industry in the continent. Their requests include:

- Top Line: public support of €0.10/W to €0.15/W of produced PV over next 10 years for both CapEx and OpEx at new and existing facilities
  - Competitive energy price of around €40.0/MWh, especially important for the energy-intensive steps of the supply chain (e.g., polysilicon and ingot)
  - At least 50% CapEx incentives for a limited initial production capacity of 30 GW throughout each step of the PV manufacturing supply chain "independent on origin of the equipment"
  - At least 50% CapEx incentives for another 70 GW capacity for local European developed, manufactured and supplied equipment and consumables, decreasing to 10% within 5 years, lasting until 2033
  - Dedicated R&D funding program for equipment development for upstream applications at substantial height: 75% for companies and 90%–100% for R&F institutes
  - An MPTC-like credit
  - Local content incentivized proportional to its value in the module (similar to the ITC/PTC bonus credits)
  - Adjustments to the state aid guidelines rules to allow member states for more and faster CapEx and OpEx support of PV manufacturing projects.

- Many of these requests are quite similar to the incentives available in the IRA. The joint statement cites the IRA and lower electricity costs in the United States as putting Europe at a disadvantage.

- Ultimately, these incentives are intended to "resolve Europe's severe energy dependence."

Sources: Taiyang News, PEi., Fraunhofer ISE press release, Joint-statement_Re-establishing-an-upstream-solar-manufacturing-value-chain-in-Europe.pdf

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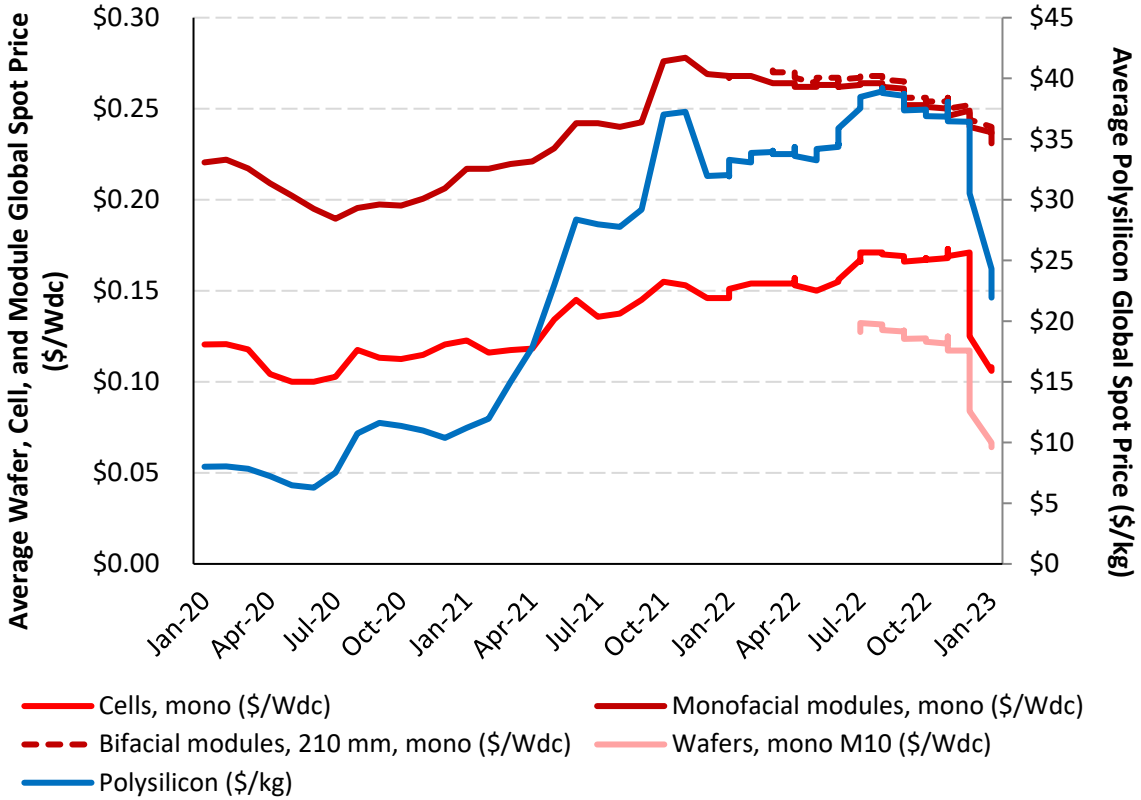
- **Polysilicon global spot prices began Q4 2022 around $37/kg but dropped 40% (to $22/kg) by mid-January, the lowest price in 1.5 years.**
  - Global wafer and cell prices dropped by 40%–50% during this period.
  - Global module prices fell only around 10% as demand from Europe decreased but Chinese demand remained relatively strong.
- **In Q3 2022, the average U.S. module price ($0.43/Wdc) was up 14% q/q and up 30% y/y, with modules trading at a 63% premium over the global spot price for monofacial monocrystalline silicon modules.**

PV Value Chain Global Spot Pricing



Polysilicon global spot prices began Q4 2022 around $37/kg but dropped 40% (to $22/kg) by mid-January, the lowest price in 1.5 years.

- Analysts were expecting lower prices as polysilicon demand decreased and production capacity increased.
- BloombergNEF predicts prices may stabilize at $10–$15/kg in 2023, which is on the border of what previous NREL analyses had considered sustainable.

Global wafer and cell prices dropped by 40%–50% during this period.

Global module prices fell only around 10% as demand from Europe decreased but Chinese demand remained relatively strong.

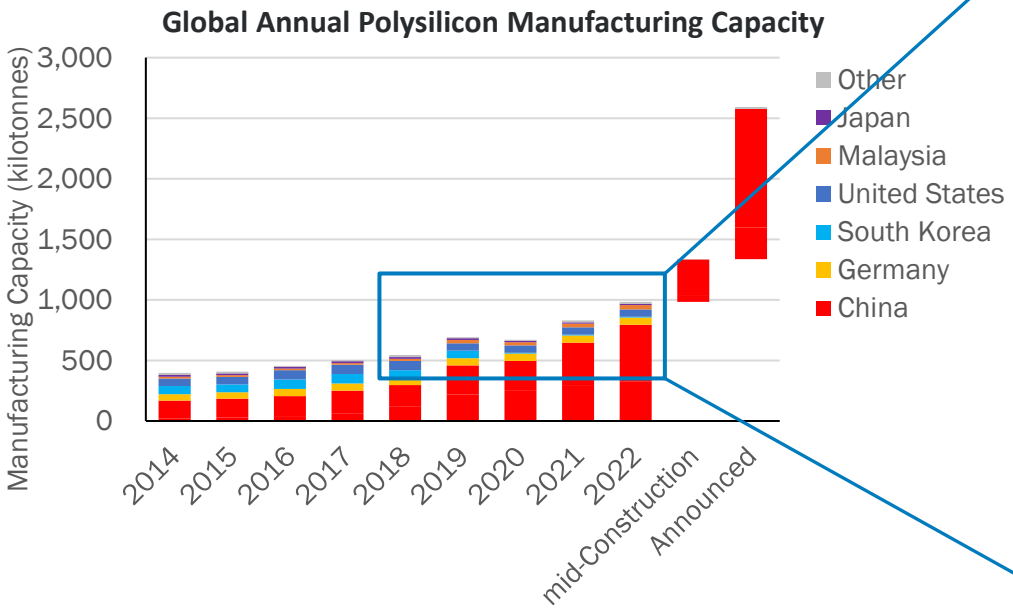
Source: BloombergNEF Solar Spot Price Index (1/13/23); BloombergNEF Bimonthly PV Index (12/6/22); PV Magazine (1/4/23); PV Tech (1/9/23, 1/12/23), NREL 2018 Cost Reduction Roadmap.

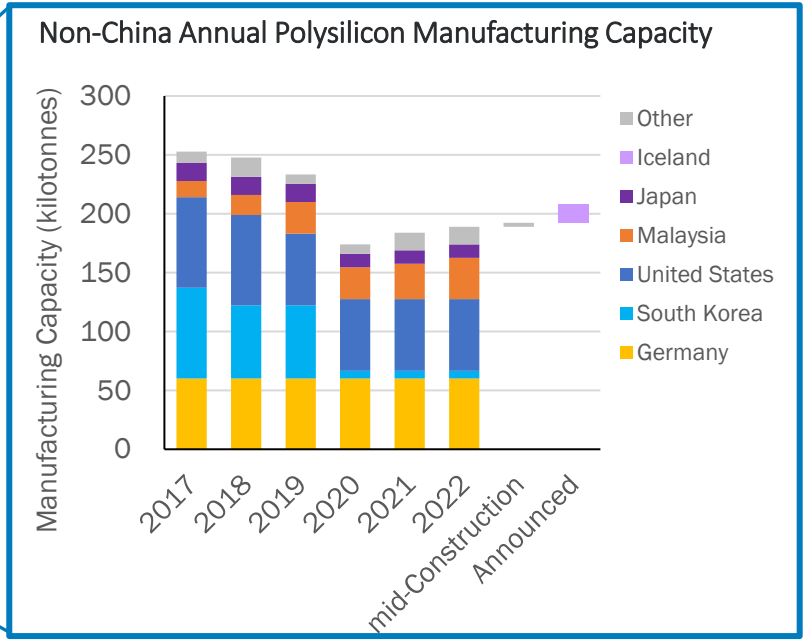
Planned Polysilicon Capacity Expansions

China's polysilicon production increased 66% in 2022 compared with 2021, and its production capacity may double in 2023.

BloombergNEF estimates polysilicon capacity in 2023 is equivalent to 500 GW of modules, and projected demand is 320 GW.

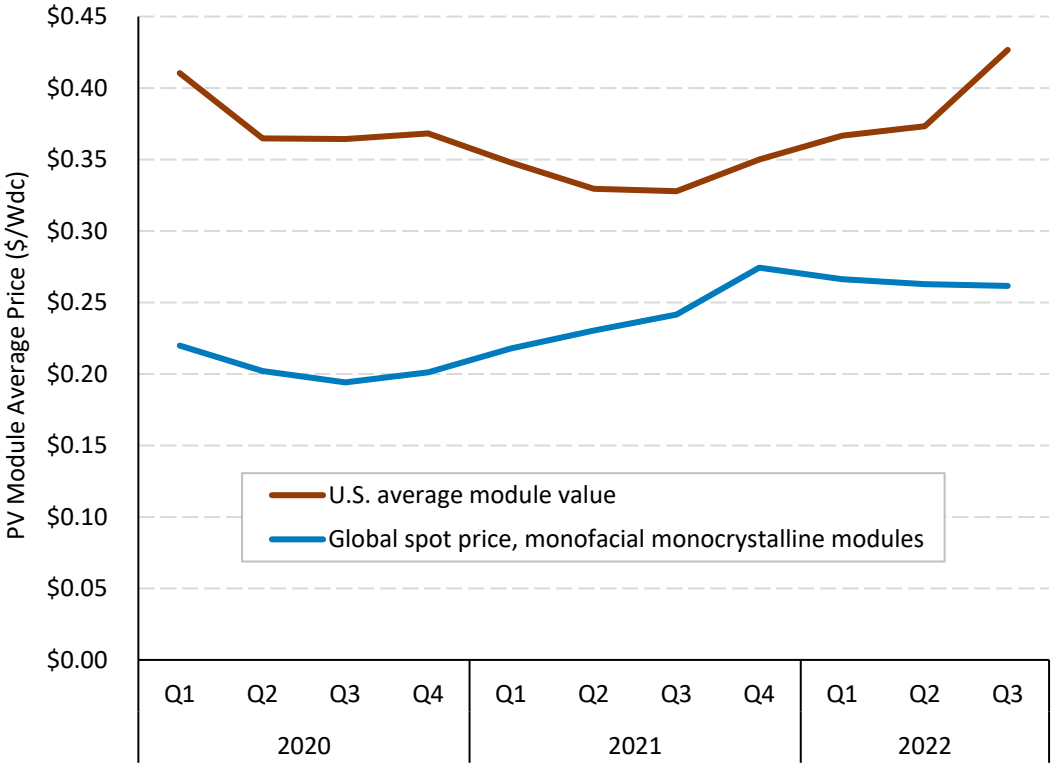
In comparison, non-China polysilicon capacity has yet to fully recover from the closing of South Korean capacity in 2019 and is not expected to expand significantly in 2023.





Source: BloombergNEF 2022, PV Magazine (1/4/23); PV Tech (1/9/23, 1/12/23)

Module Prices: Global versus United States



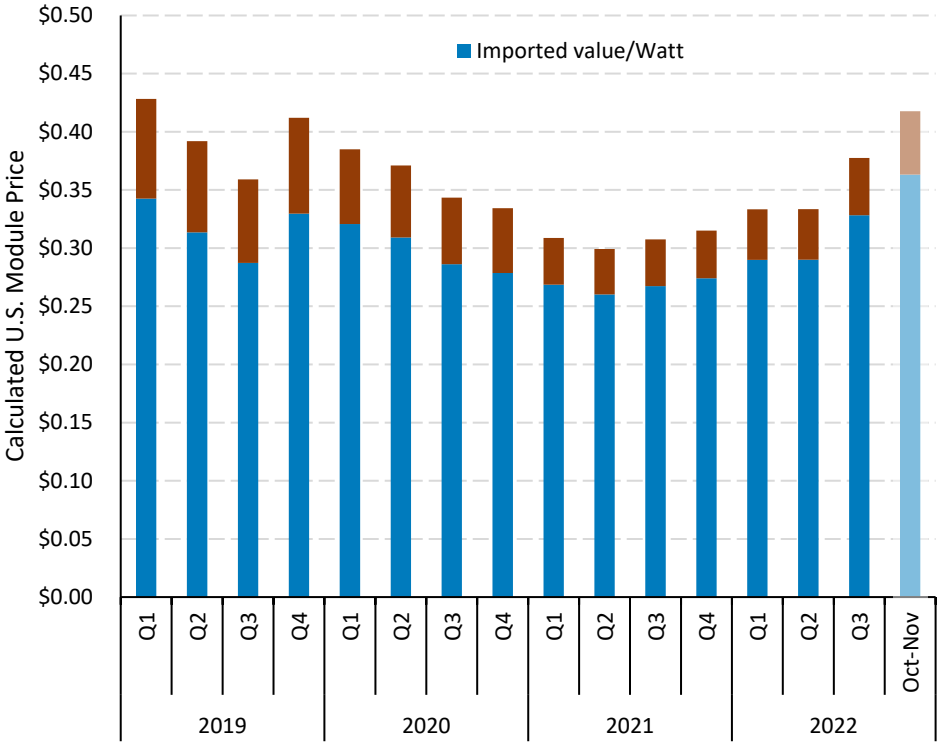
- In Q3 2022, the average U.S. module price ($0.43/Wdc) was up 14% q/q and up 30% y/y, with modules trading at a 63% premium over the global spot price for monofacial monocrystalline silicon modules.
- The disparity between U.S. and global module prices in 2022 reflects the tumultuous U.S. policy and supply and demand context.
  - The U.S. Department of Commerce anti-circumvention investigation stalled module shipments from Southeast Asia early in Q2 2022.
  - An executive order in early June exempting those Southeast Asian modules from tariffs for 2 years caused a spike in demand and prices from that region.
  - The Uyghur Forced Labor Prevention Act came into force on June 21, causing renewed supply constraints and price increases for modules from Southeast Asia.

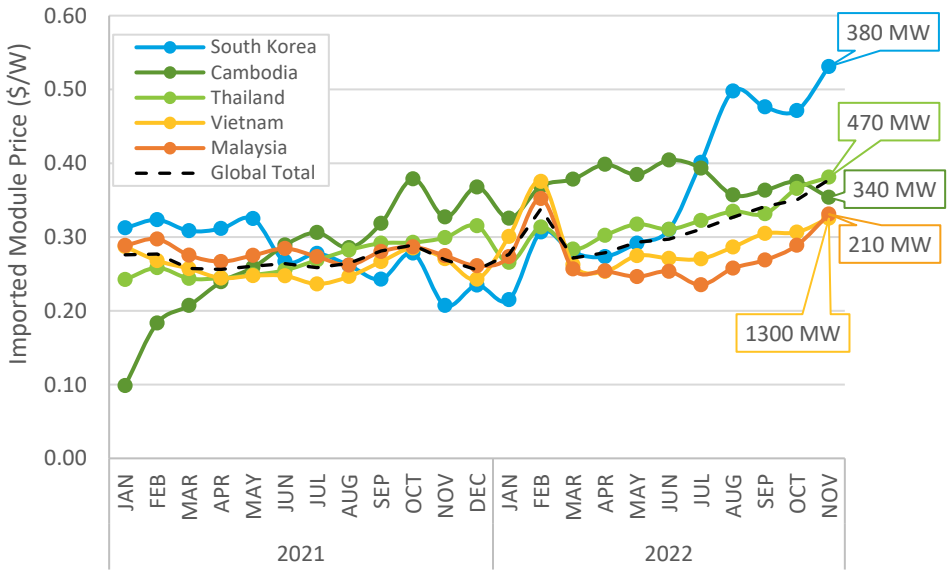
Source: BloombergNEF Solar Spot Price Index (1/13/23); BloombergNEF Bimonthly PV Index (9/27/22); EIA Monthly Solar Photovoltaic Module Shipments Report (1/17/23); Wood Mackenzie & SEIA, US Solar Market Insight: Q3 2022 (9/22).

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 has continued to rise in Q3 and is expected to rise sharply again in Q4.

– After a spike in prices in February, module prices have risen in all major countries of import except for Cambodia, with prices of imports from South Korea rising the most sharply.

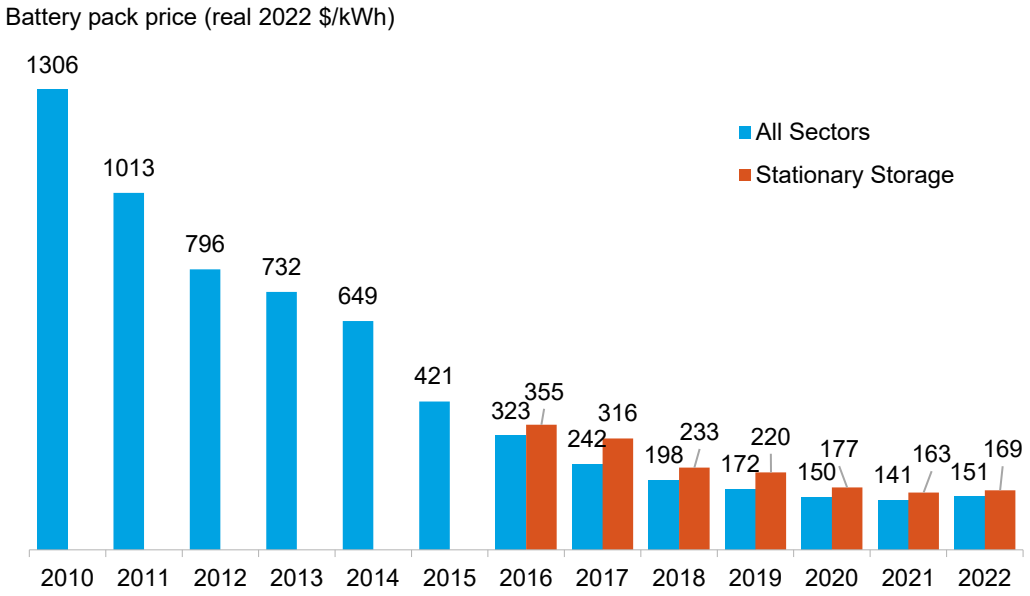




Note: Manual corrections were made to three values due to suspected data entry errors for HTS code 8541430010: Cambodia (February 2022), Malaysia (June 2020), and Vietnam (July 2019).

Sources: Imports by HTS code: 8541460015(2018-2021)/8541430010(2022-), Customs Value and Second Quantity (watts) from the U.S. International Trade Commission DataWeb, the U.S. Census Bureau USA Trade Online tool and corrections page as od 1/23/23.

Average Lithium-ion Battery Pack Price, 2010–2019



Sources: BloombergNEF. "2022 Lithium-Ion Battery Price Survey."

- From 2010 to 2021, average battery pack prices dropped 89%, falling in price every year.
  - From 2016 to 2021, average battery pack prices within the stationary storage sector decreased 54%.
- However, from 2021 to 2022, average battery pack prices increased 7% across all sectors and 4% for stationary storage applications.
- BloombergNEF cited inflation and pandemic-related supply chain constraints (particularly lithium carbonate used for lithium-iron phosphate cells) as the primary drivers of increased costs.
  - They also stated that these impacts were somewhat muted for stationary storage applications as Chinese companies squeezed their margins to continue to win orders.
  - However, pricing dynamics continue to be a disadvantage for stationary storage due to lower volumes relative to the electric vehicle industry.
- To reduce costs, the battery industry continues to pursue new battery chemistries and to improve cell and pack integration and new manufacturing processes.
  - This strategies may be adopted sooner due to the rise in raw material costs.

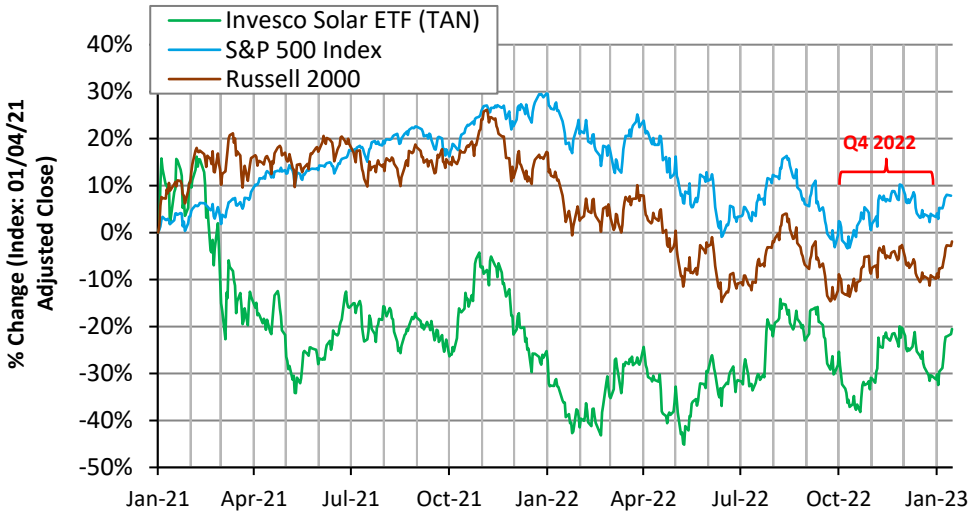
Agenda

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

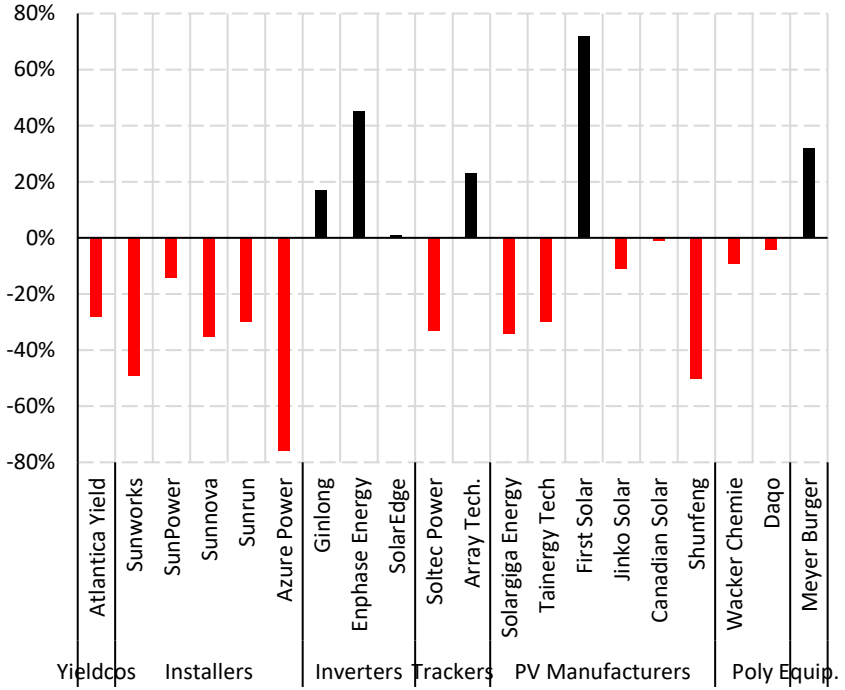
- **Solar stocks represented by the Invesco Solar ETF fell 14% to their Q4 low in late October amid expectations of higher PV construction costs before rising 30% by late November due in part to California's revised net metering proposal. Solar stocks performed better over the entire year, down 7% versus down 20% for the broader market.**
- **SREC bid prices in Washington, D.C. dipped $100 in mid-2022 but then quickly rebounded.**

Stock Market Activity

Solar stocks represented by the Invesco Solar ETF fell 14% to their Q4 low in late October amid expectations of higher PV construction costs before rising 30% by late November due in part to California's revised net metering proposal. After sliding more dramatically than the broader market in December, solar stocks ended down 3% for the quarter while the broader market ended up about 4%. However, solar stocks performed better over the entire year, down 7% versus down 20% for the broader market.



Individual Stock Performance (Q1–Q4 2022)

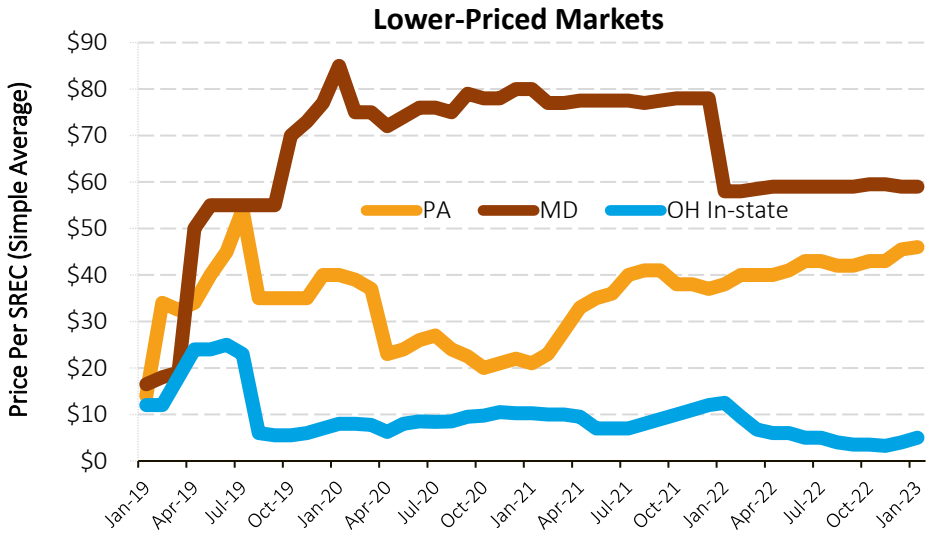


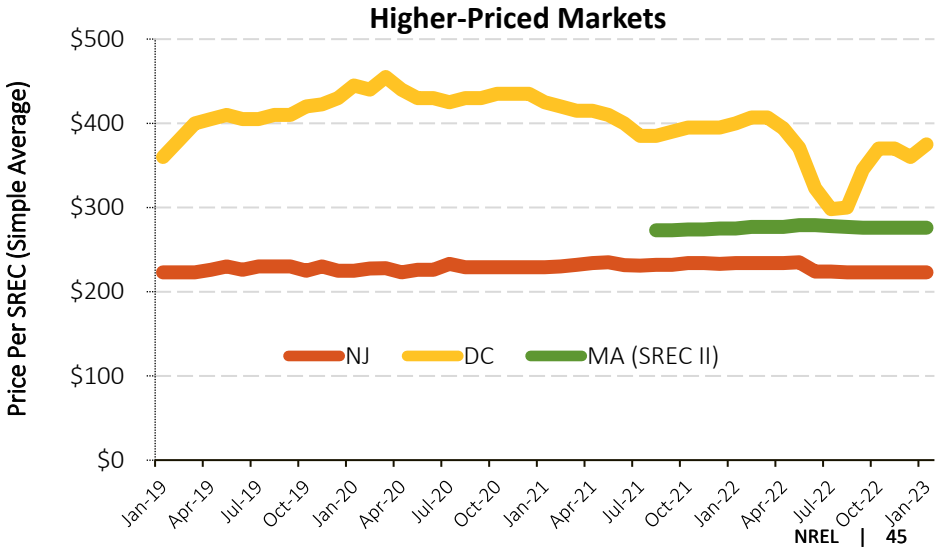
Note: The TAN index is weighted toward particular countries and sectors. As of 1/18/23, 49% of its funds were in U.S. companies and 21% were in Chinese companies. Its top 10 holdings, representing 56% of its value, were First Solar, SolarEdge, Enphase, Sunrun, Xinyi, GCL, Array Technologies, Shoals, Daqo, and Encavis.

Sources: Invesco (1/18/23); Mercom, Solar Market Intelligence Report (11/28/22); PV Magazine (11/22).

SREC Pricing

- SREC bid prices in Washington, D.C. dipped $100 in mid-2022 but then quickly rebounded.
  - The price decline and increase may indicate uncertainty of an oversupply of SRECs, as more than half of D.C.'s solar capacity has been installed in the past 2 years.
- Other SREC prices stayed relatively flat during this period.
- Active SREC programs have closed in New Jersey, Massachusetts, and Ohio.

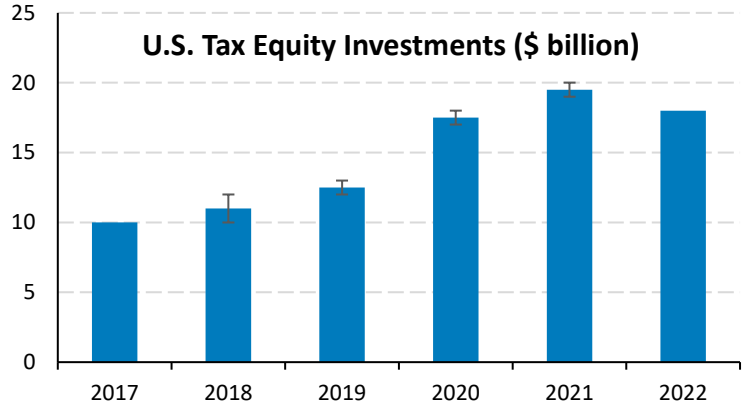




Source: SRECTrade, https://www.srectrade.com/, accessed 2/3/23.

Cost of Capital, Tax Equity (Norton, Rose, Fulbright)

- Tax equity investors invested $18 billion in 2022 ($11 billion in wind and $7 billion in solar)—down 10%, y/y. Investors attributed the downturn to (1) supply chain difficulties, (2) tariff issues, and (3) investors waiting to see the rules for the new credits from the IRA. A significant amount of time was also spent converting PV deals to using the PTC (from the ITC), which is now allowed by the IRA.
- Tax equity demand for 2023 is expected to be $20 billion–$21 billion, though it may take some projects 9 months to arrange deals as there is a significant backlog of projects.
- Tax equity represented roughly 35% of solar project costs in 2022 (±5%), but the range will likely have a much higher end due to the use of PTC (pushing projects to 45%) and bonus credits.
- PTC projects are bit more complicated than ITC projects because they are 10 years and tied to production. So, the offtaker, equipment, and transmission concerns all become more important.
- Tax equity flip yields increased again in 2022, up from 6.75%–7.5% in 2021, pushed by increases in interest rates and competition for tax equity.
- *Transferability* of tax credits now offered by the IRA is expected to bring new investors from U.S. corporations who want to manage their taxes but do not want to set up a tax equity shop. Banks still expect to manage the deals.



- It will likely take 6–18 months to develop a tax credit transfer market because it will take time to educate investors. A large discount on the credits is expected as developers will want long-term commitments, and many companies do not have a long-term idea of their tax liabilities.
- Tax equity deals for just depreciation are not expected as the deals would be too small.
- Banks are already starting to work on deals with domestic content and energy community credits, as well as deals with storage taking the ITC and PV taking the PTC. However, final deal terms are awaiting further IRS guidance to come out this year.
- Banks are planning to do tax equity deals with new credits (48C, 45X, 45V, 45Z), but they expect developing deals to take 12–18 months.

Sources: Norton Rose Fulbright Cost of Capital: 2023 Outlook.

Cost of Capital, Bank Debt (Norton, Rose, Fulbright)

- Unlike the tax equity market, project finance bank debt in the energy sector reached a record level in 2022, with $96 billion in deals, up 43%.
- Though there were fewer deals in 2022 (211) than in 2021 (224), there were many large-scale deals outside the environmental, social, and governance sector, For example, $20 billion of deals were done for liquefied natural gas, in large part due to the war in Ukraine. There were also others deals for airports and semiconductors.
- Debt service coverage ratios for solar project finance loans were 1.20–1.25 for utility-scale projects and 1.3–1.5 for community solar projects (they were 1.30–1.35 for wind).
- Banks are no longer basing the price of deals on LIBOR, but now instead use SOFR. In January 2023, the daily SOFR was trading at 4.3%. Total fees on top of that rate generally range between 2.25% and 3.00%, putting the total coupon between 6.5% and 7.5%.
- Banks are now also willing to offer loans with some merchant risk (i.e., a portion of future electricity sales do not have a predetermined price).

Sources: Norton Rose Fulbright Cost of Capital: 2023 Outlook.

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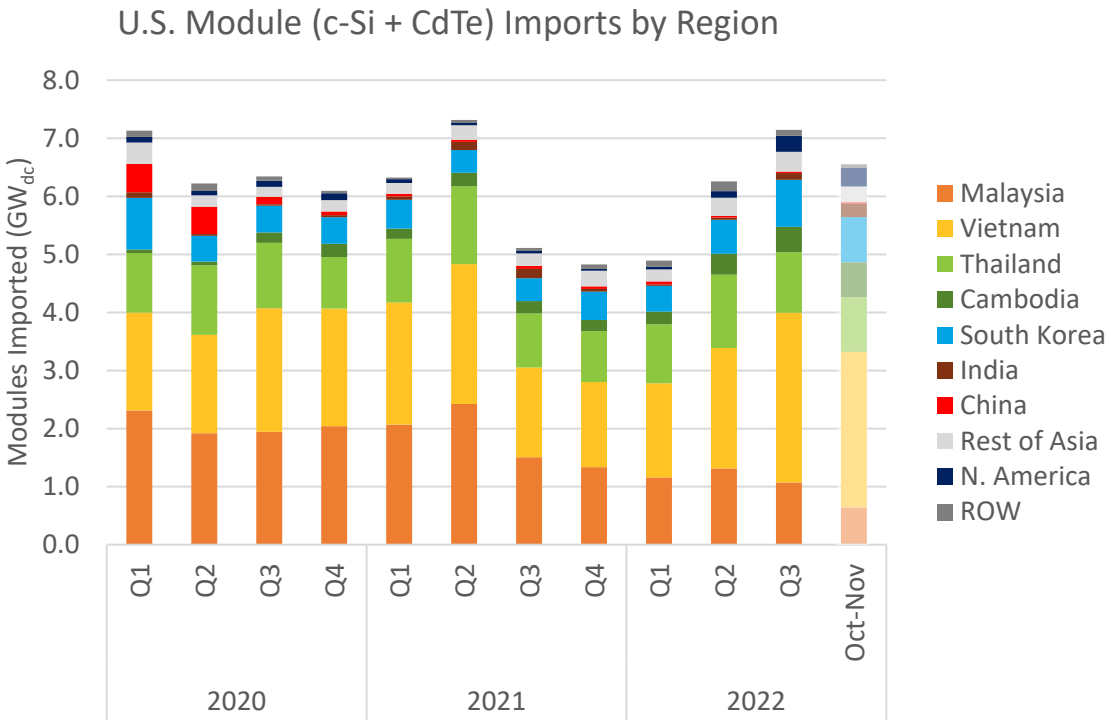
7. **U.S. PV Imports**

- **18.3 GWdc of PV modules were imported into the United States in the first 9 months of 2022, down 2% y/y.**
  - Most panels imported were exempt from Section 201 duties and were therefore likely bifacial. A significant number of thin-film modules were also imported.
- **1.8 GWdc of cells were imported in the first 9 months of 2022, down 18% y/y.**
  - Despite the renewal of the Section 201 tariffs in February, which raised the quota exemption from 2.5 GW_{dc} to 5.0 GW_{dc}, there has not been a significant uptick in the import of solar cells. Imports are on track to match those of 2021.

U.S. Module Imports by Region



In Q3 2022, U.S. module imports continued their upward trend (+14%, 890 MW_{dc} q/q), totaling 18.3 GW_{dc} in Q1–Q3 2022 (-2% y/y, -460 MW_{dc}).

- Import levels had decreased after the withhold release order (WRO) on PV cells and modules was announced in late Q2 2021. Additionally, many manufacturers in Southeast Asia had reduced production levels earlier in the year with the announcement of a U.S. antidumping and countervailing duties circumvention investigation. When the 2-year waiver was announced in June, manufacturers said it would take time to ramp production back up.
- As in Q2, the Q3 increase was predominantly the result of increased imports from Vietnam (+41% q/q, 847 MW).
- Imports from Canada and Mexico grew nearly threefold in Q1–Q3 2022 (+290 MW y/y).

Though Q4 is not yet complete, it has already nearly matched Q3 imports.

- This has been mainly the result of imports from Vietnam, which totaled nearly 2.7 GW (2.2 GW c-Si + 0.5 GW thin film) over October and November.
- Imports from India have also doubled from Q3 to the as-yet-incomplete Q4 (+120 MW).

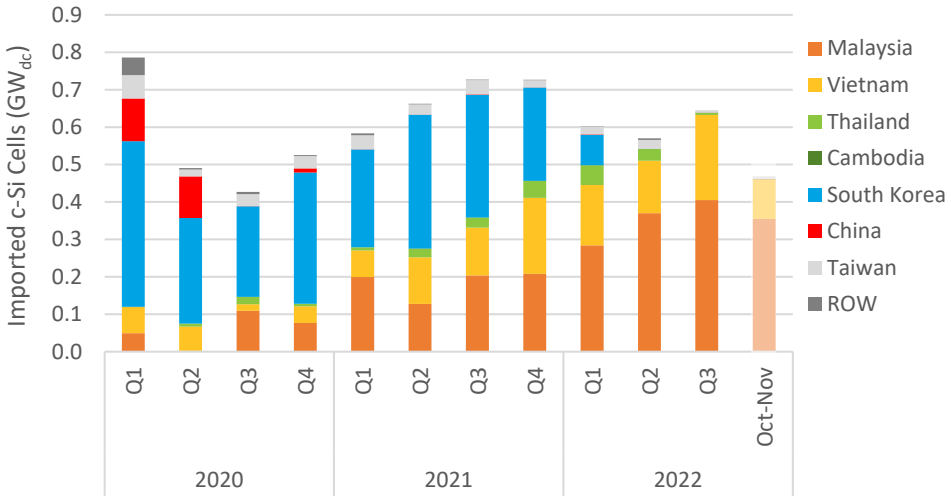
Sources: Imports by HTS code: 8541460015(2018-2021)/8541430010(2022-) and 8541460035(2018-2021)/8541430080(2022-), Second Quantity (watts) from the U.S. International Trade Commission DataWeb as well as the U.S. Census Bureau USA Trade Online tool and corrections page as of 1/23/23.

c-Si Cell Import Data Q1–Q3 2022

According to U.S. Census data, 1.8 GW_{dc} of cells were imported in Q1-Q3 2022. Quarterly cell imports grew for the first time in a year in Q3 2022 (+74 MW_{dc}, +13% q/q).

- This growth was almost entirely the result of increased imports from Malaysia (350 MW in Q3 alone), which have been ramping up since Q2 2021.

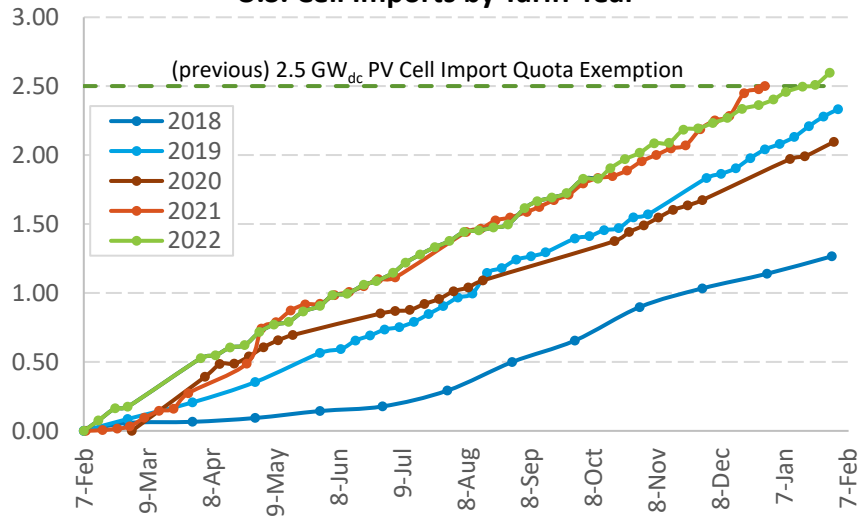
U.S. Cell Imports by Region



Though only October and November data are available, imports in Q4 are on track to continue this growth.

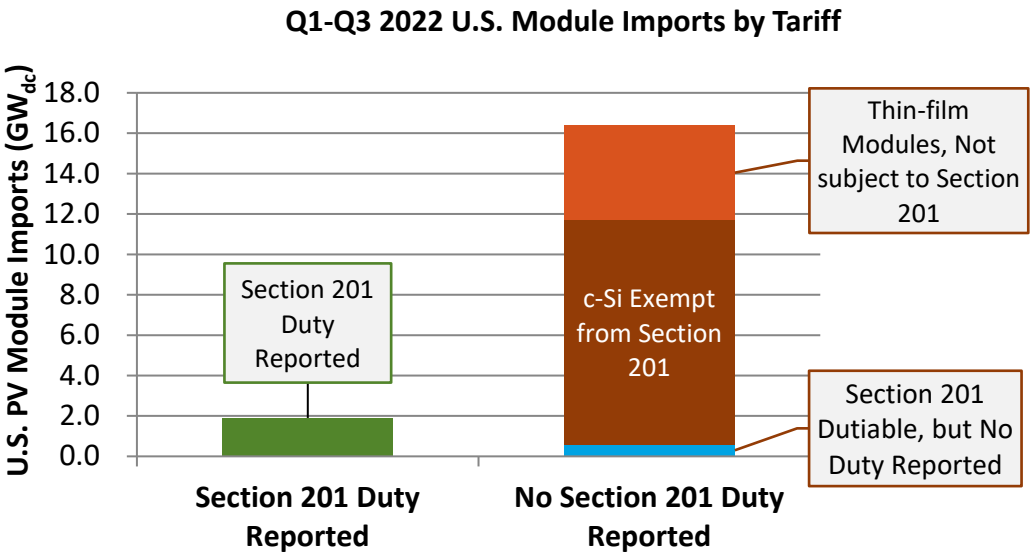
Indeed, according to CBP Commodity Status Reports, cell imports since last February (when the Section 201 Tariffs were renewed and the quota exemption was raised) passed 2.5 GW_{dc} the week of January 16. This is somewhat slower, but still in-line with cell imports in 2021.

U.S. Cell Imports by Tariff Year



Sources: Imports by HTS code: 8541460025(2018-2021)/8541420010(2022-), Second Quantity (watts) from U.S. Census Bureau USA Trade Online tool and corrections page as of 10/20/22; U.S. Customs and Border Protection Commodity Status Reports February 2019–January 2023.

Q1–Q3 2022 U.S. Module Imports by Tariff



- In Q1–Q3 2022, only 10% (1.9 GW_{dc}) of modules reported a tariff, compared to 62% (11.5 GW_{dc}) in Q1–Q3 2021.
  - Most of the modules that did not were c-Si technology panels exempt from Section 201 tariffs (11 GW_{dc}, 61%) or thin-film and not subject to tariffs (4.7 GW_{dc}, 26%).
  - The c-Si imports were likely bifacial panels, which the Biden administration exempted from Section 201 duties in February 2022.
  - CdTe panels are not subject to the various duties to which c-Si modules are subject, and they do not have a supply chain in locations currently scrutinized over the use of forced labor.
- In Q3 2022, imports of c-Si panels exempt from Section 201 tariffs increased nearly 300 MW_{dc} (+8%), cooling a nearly exponential trend over the prior three quarters.
- Q1–Q3 2022 imports of thin-film modules were up 26%, or nearly 1 GW_{dc} y/y.

Notes: 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 8541406015/8541430010, and technologies not applicable reported under HTS code 854140603. We assumed all panels subject to Section 201 duties are reported under "Dutiable- HS chapter 99." Manual corrections were made to the following value due to suspected data entry errors for HTS code 8541430010: Cambodia February 2022.

Sources: Imports by HTS code: 8541460015(2018-2021)/8541430010(2022-) and 8541460035(2018-2021)/8541430080(2022-), Second Quantity (watts), and Rate Provision Code from the U.S. International Trade Commission DataWeb as well as the U.S. Census Bureau USA Trade Online tool and corrections page as of 1/19/23.

Thank You

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List of Acronyms and Abbreviations

AD: antidumping
ac: alternating current
ASP: average selling price
BGS: Boston Government Services, LLC
CapEx: capital expenditures
c-Si: crystalline silicon
C&I: commercial and industrial
CC: combined cycle
CBP: U.S. Customs and Border Protection
CdTe: cadmium telluride
CEC: California Energy Commission
CPUC: California Public Utility Commission
CSP: concentrating solar power
CT: combustion turbine
CVD: countervailing
DAC: disadvantaged communities
dc: direct current
DOE: U.S. Department of Energy
EIA: U.S. Energy Information Administration
ETF: exchange traded fund
GW: gigawatt
GWh: gigawatt-hour
H1: first half of year
H2: second half of year
HTS: harmonized tariff schedule
IEEFA: Institute for Energy Economics and Financial Analysis
IRA: Inflation Reduction Act of 2022
IRS: Internal Revenue Service
ITC: investment tax credit
kW: kilowatt
kWh: kilowatt-hour
LBNL: Lawrence Berkeley National Laboratory
LIBOR: London interbank offered rate
MPTC: manufacturing production tax credit
MW: megawatt
MWh: megawatt-hour
NEM: net energy metering
NREL: National Renewable Energy Laboratory
OpEx: operating expenditure
PPA: power purchase agreement
PTC: production tax credit
PV: photovoltaics
Q: quarter
q/q: quarter 0ver quarter
R&D: research and development
SEIA: Solar Energy Industries Association
SETO: Solar Energy Technology Office
SOFR: secured overnight financing rate
SREC: solar renewable energy certificate
TAN: Invesco Solar ETF
USD: U.S. dollars
USDA: U.S. Department of Agriculture
W: watt
WRO: withhold release order
y/y: year over year
YTD: year to date

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Nextracker & Atkore Commission Manufacturing Line In Arizona | TaiyangNews
Steel Fab Reopens In US For Nextracker | TaiyangNews
CHERP Builds First Nonprofit Solar Panel Factory | The Claremont COURIER (claremont-courier.com)
Convalt sets ambitious production goals at Watertown site | Business (nny360.com)
Convalt Energy Receives Bridge Gap Loan from JCIDA for Hounsfield Project | Business (nny360.com)
US Solar Backsheet Maker Expanding Capacity | TaiyangNews
Enphase Energy To Open Manufacturing Lines In US | TaiyangNews
First Solar To Invest Up to $1.2 Billion in Expanding U.S. Solar Manufacturing by 4.4 GW | pv magazine USA (pv-magazine-usa.com)
Expanding Before Opening 2nd First Solar Plant in Lake Twp. Gets OK to be Bigger | News | sent-trib.com
Fuyao Glass To Expand Production Capacity In The US | TaiyangNews
GAF Energy Breaks Ground on Texas Solar Roofing Plant | pv magazine USA (pv-magazine-usa.com)
USA: 6 GW Solar Tracker Manufacturing Fab Planned | TaiyangNews
Hanwha To Produce Module Encapsulants in US | TaiyangNews
Hanwha Q Cells to Build US Solar Module Factory, Expand Cell Capacity in South Korea | pv magazine International (pv-magazine.com)
https://www.pv-tech.org/heliene-president-opens-up-on-us-manufacturing-plans-post-ira/
Canada's Heliene opening Its Second U.S. Solar Panel Factory | Reuters
Heliene Boosts U.S. Solar Supply Chain with Expansion of Minnesota Facility (renewableenergyworld.com)
Ice Industries Invests in New Ohio Facility to Serve America's Largest Solar Manufacturer | Ice Industries
New JM Steel manufacturing plant will have a Nextracker tracker production line – pv magazine USA (pv-magazine-usa.com)
https://www.solarpowerworldonline.com/2022/03/maxeon-still-has-sights-set-on-u-s-solar-manufacturing-hub/
OCI To Invest $40 Million to Expand US Solar Module Production Facilities | KED Global
Mitrex to Build N.Y. Solar Product Manufacturing Facility | SBIZ • Sustainable Biz Canada
Gov. Kemp: Solar Tech Company NanoPV to Open Manufacturing, Distribution Operations in Sumter County, Create Over 500 Jobs | Governor Brian P. Kemp Office of the Governor (georgia.gov)

List of Manufacturing Announcements (page 2)

Philadelphia Solar Announces 1 GW PV Panel Manufacturing Facility Investment Plan in U.S. (enfsolar.com)
PV Hardware Plans 6GW Solar Tracker Manufacturing Factory in Texas: PV Tech (pv-tech.org)
REC Silicon Signs Second Supply Agreement for U.S. Metal-Grade Silicon (solarpowerworldonline.com)
Reliance Industries Acquires REC Group, Plans 1 GW U.S. Module Facility | pv magazine USA (pv-magazine-usa.com)
New N-Type TOPCon Solar Module Fab in Texas, US | TaiyangNews
Silfab Plans to Start Solar Cell Manufacturing in the United States, but Commerce investigation Has Halted Progress (solarpowerworldonline.com)
Silfab Solar Doubles US Solar Panel Manufacturing Capacity | Press, SILFAB SOLAR
SPI Energy Will Start 1.5-GW Silicon Wafer Manufacturing Site Stateside by 2023 (solarpowerworldonline.com)
SPI Energy Accelerates Growth of Solar Module Manufacturing Capacity to Meet Strong Demand (yahoo.com)
Sun Pacific to Develop a U.S. Solar Panel Manufacturing Facility | ROI-NJ
Toledo Solar To Expand US Manufacturing Capacity | TaiyangNews
Governor Hochul Announces Plans for Ubiquity Solar to Establish U.S. Manufacturing Operations at Former IBM Huron Campus in Broome County | Governor Kathy Hochul (ny.gov)
Biden's Climate Push Lures Indian Firm to Make Panels in US (bloombergtax.com)
Enel Intends to Build Solar Panel Manufacturing Facility in the US (enelnorthamerica.com)
Canadian Solar Inc. (CSIQ) Q3 2022 Earnings Call Transcript | Seeking Alpha
New Solar Panel Manufacturer To Set Up in Georgia with 500-MW Facility (solarpowerworldonline.com)
CubicPV Announces Plans To Build Silicon Wafer Facility in the United States | CubicPV
Korean Solar Company Plans To Build $2.5 Billion Plant in Georgia | The New York Times (nytimes.com)
JA Solar plans To Build 2 GW Solar Module Factory in US | pv magazine International (pv-magazine.com)