NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Spring 2023 Solar Industry Update

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Photo by Werner Slocum, NREL 74637

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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

- IEA reported that in 2022, 231 GWdc of PV was installed globally, bringing cumulative PV installs to 1.2 TWdc.
  - China's annual PV installations grew 57% y/y in 2022, representing 42% of total global demand, with the majority coming from distributed PV.
  - The U.S. was the second-largest market in terms of cumulative and annual installations.
- Analyst project 2023 annual installations to grow to more than 300 GW and by 2025 more than 400 GW.

U.S. PV Deployment

- In 2022, PV represented approximately 46% of new U.S. electric generation capacity, compared to 4% in 2010.
- Solar still represented only 9.0% of net summer capacity and 4.7% of annual generation in 2022.
- However, 16 states generated more than 5% of their electricity from solar, with California leading the way at 27.3%.
- The United States installed 17.0 GWac (20.2 GWdc) of PV in 2022, ending the year with 110.1 GWac (140.6 GWdc) of cumulative PV installations.
- The United States installed approximately 14.1 GWh, 4.8 GWac of energy storage onto the electric grid in 2022, up 34% y/y.

PV System and Component Pricing

- The median system price for a select group of utility-scale PV projects in 2022 was $1.49/Wac—up 13% y/y.
- The median reported price by EnergySage for residential PV systems increased 6.3% y/y to $2.85/Wdc – the third straight period of increase, after never having done so before.
- After plunging to a 1.5-year low of $20/kg in mid-January, global polysilicon spot prices rebounded to $30/kg in mid-February and then dropped to $24/kg by mid-April.
- Global module prices have declined steadily since fall 2022 despite strong demand, reaching lows in April 2023 that have not been seen for 2 years.

Global Manufacturing

- In 2022, global PV shipments were approximately 283 GW—an increase of 46% from 2021.
- In 2022, 96% of PV shipments were mono c-Si technology, compared to 35% in 2015.
- N-type mono c-Si grew to 51% - up from 20% in 2021 (and 5% in 2019).
- In 2022, the United States produced a around 5 GW of PV modules.

U.S. PV Imports

- According to U.S. Census data, 28.7 GWdc of modules and 2.5 GWdc of cells were imported in 2022, an increase of 21% y/y (+5 GW) and 7% y/y (178 MW), respectively.
- Collectively, Malaysia, Vietnam, Thailand, and Cambodia represented 73% of c-Si module imports (75% including c-Si cells).
- According to U.S. Census data, 2.5 GWdc of cells were imported in 2022. Quarterly cell imports grew for the second quarter in a row in Q4 2022 (+60 MWdc, +9% q/q).
- In 2022, only 10% (2.7 GWdc) of modules reported a tariff, compared to 56% (13.2 GWdc) in 2021.

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

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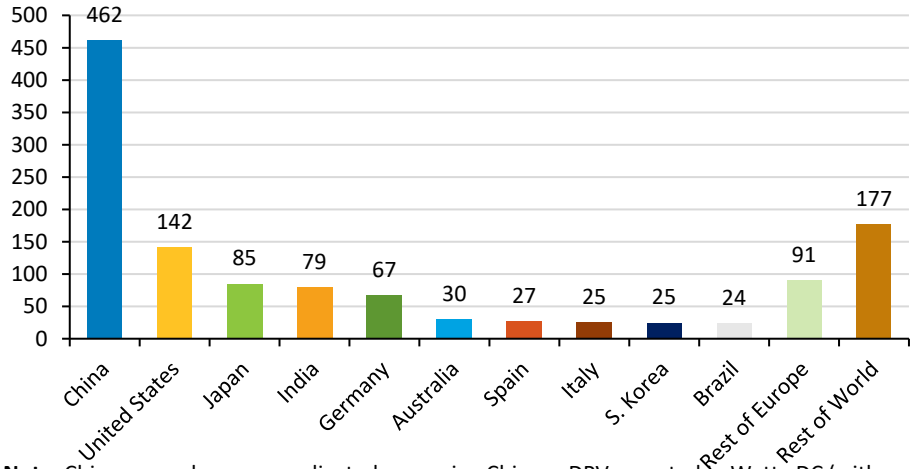
- **IEA reported that in 2022, 240 GWdc of PV was installed globally, bringing cumulative PV installs to 1.2 TWdc.**
  - **China's annual PV installations grew 93% y/y in 2022, representing 44% of total global demand, with the majority coming from distributed PV.**
  - **The U.S. was the second-largest market in terms of cumulative and annual installations.**
- **Analysts project 2023 annual installations to grow to more than 300 GW and by 2025 more than 400 GW.**
- **At the end of 2022, global CSP capacity reached approximately 6.4 GW, with 1.3 GW under construction.**

Top PV Markets

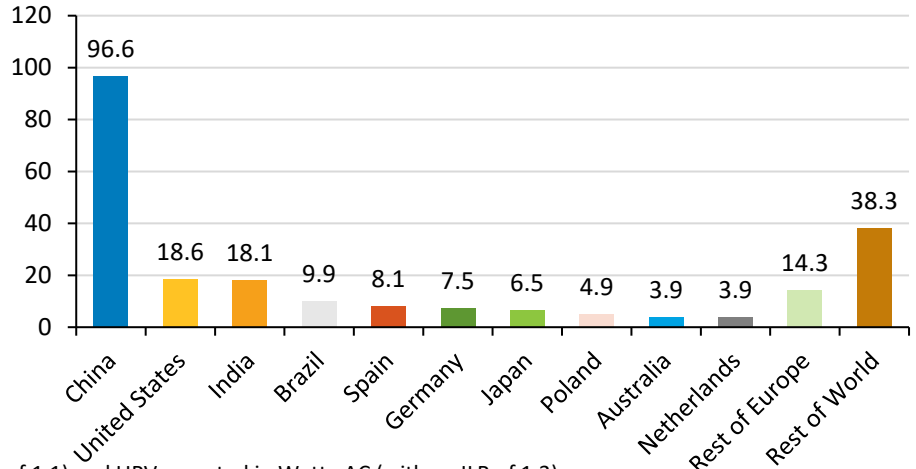
- The leading 10 markets in terms of cumulative capacity remained relatively unchanged between 2021 and 2022.
  - Brazil jumped ahead of Vietnam for the 10th spot in 2022.

- China's annual PV installations grew 57% y/y in 2022, representing 42% of total global demand.
- In 2022, despite a market contraction, the United States was the second-largest PV country market in terms of both cumulative and annual installations.
  - The EU, however, was the second-largest market, with 209 GWdc of cumulative installations (17% of global installations and 3 countries in the top 10) and 38.7 GWdc annual installations (17% of global installations and 4 countries in the top 10) in 2022.

Cumulative PV Deployment - 2022 (1,233 GWdc)



Annual PV Deployment - 2022 (231 GWdc)



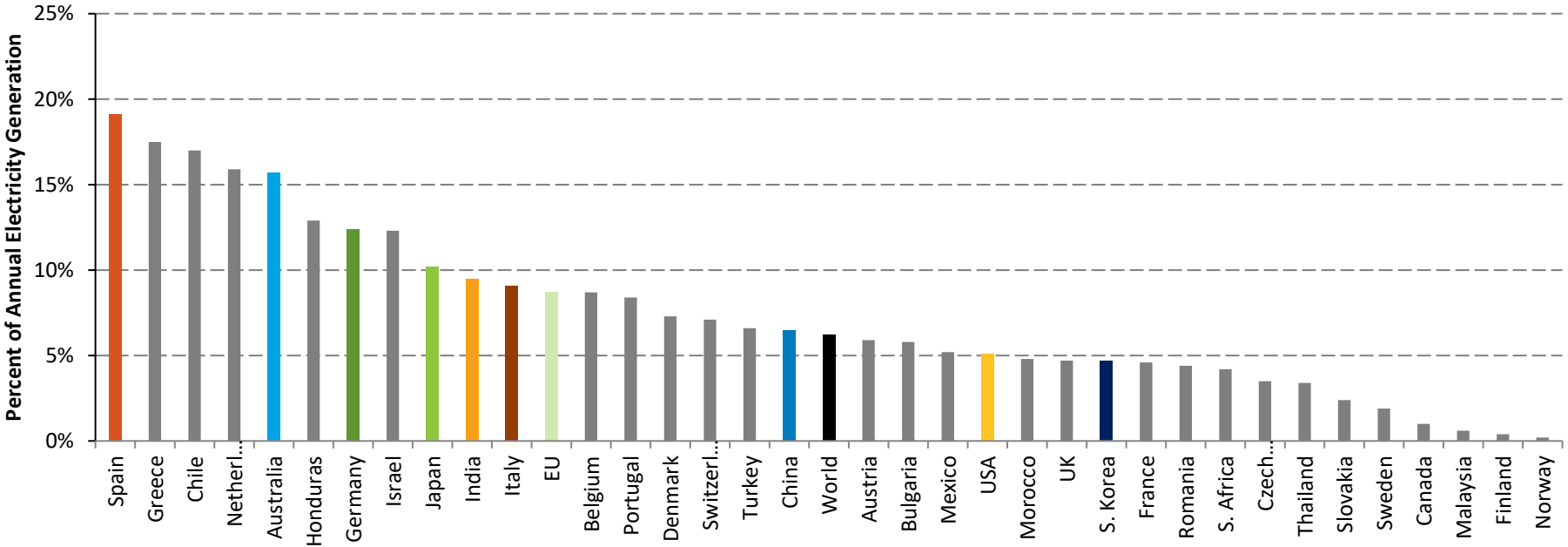
Note: Chinese numbers were adjusted, assuming Chinese DPV reported in Watts-DC (with an ILR of 1.1) and UPV reported in Watts-AC (with an ILR of 1.3).

Sources: IEA, Snapshot of Global PV Markets: 2023; Trends in Photovoltaic Applications 2022.

Global PV Penetration

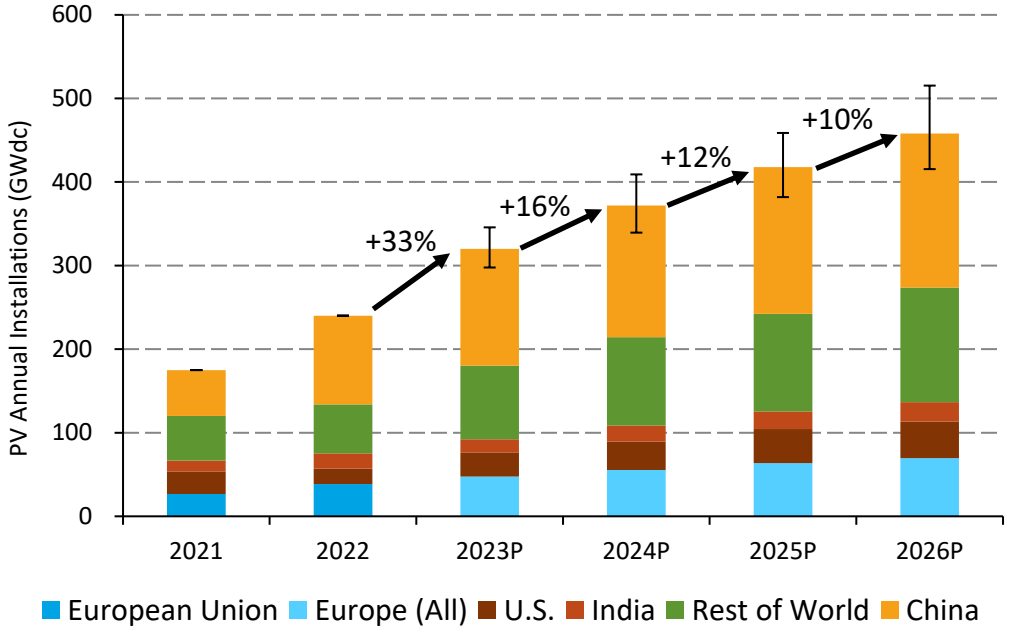
- IEA estimates that in 2022, 6% of global electricity generation came from PV.

- The United States, despite being a leading PV market, is below the global average and other leading markets in terms of PV generation as a percentage of total country electricity generation, with 5%.
  - If California were a country, its PV contribution (28%) would be the highest.



Source: IEA, Snapshot of Global PV Markets: 2023.

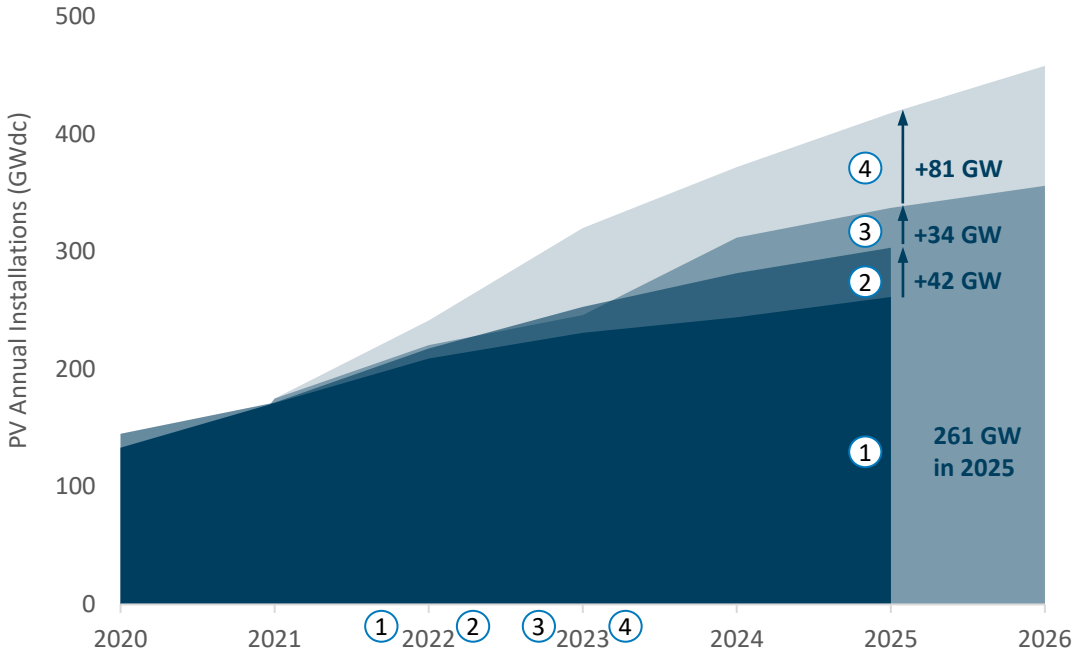
Annual Global PV Demand



Notes: E = estimate, P = projection. Colored bars represent median projections for region/country-level estimates. Error bars represent high and low global projections. Not all sources have data for all categories.
Sources: BNEF, 1Q 2023 Global PV Market Outlook, 2/28/23; Goldman Sachs Equity Research, America's Clean Technology: Solar, 2023 Outlook, 12/18/22; IEA, Snapshot of Global PV Markets: 2022, 4/22; IEA, Snapshot of Global PV Markets: 2023, 4/23; U.S. Energy Information Administration, Annual Energy Outlook 2023, 3/16/23; U.S. Energy Information Administration, Monthly Energy Review, 12/22; Wood Mackenzie and SEIA, US Solar Market Insight, 2022 Year in Review, 3/23.

- About 240 GWdc of PV were installed globally in 2022.
- Analysts project continued increases in annual global PV installations.
  - 320 GWdc in 2023
  - 372 GWdc in 2024
  - 418 GWdc in 2025
  - 458 GWdc in 2026.
- Analysts who provided global projections 1 year ago increased those projections this year (e.g., by 34%–38% for 2025 projections).
- China, Europe, the United States, and India account for about 70% of global PV installations over the period shown.

Change in Recent Global PV Demand Projections



Reported Drivers of Growth in Installed PV Projections

1. Projections in Mid to Late 2021: COVID-19 coming under control, improving supply chains, reduced geopolitical trade risks.

2. Projections in Early 2022: invasion of Ukraine by Russia, increasing desire for energy security, increasing conventional energy prices, improving supply chains, higher national PV targets.

3. Projections in Mid to Late 2022: increasing conventional energy prices, increasing polysilicon supply, declining module prices, adjusting for underestimation of global market in official installation statistics.

4. Projections in Late 2022 to Early 2023: oversupply throughout supply chain, declining module prices, large module inventories, IRA and other U.S. policies, energy cost inflation in Europe, supply chain normalization in China, potentially explosive growth constrained only by local conditions (permitting, interconnection, labor, financing, etc.).

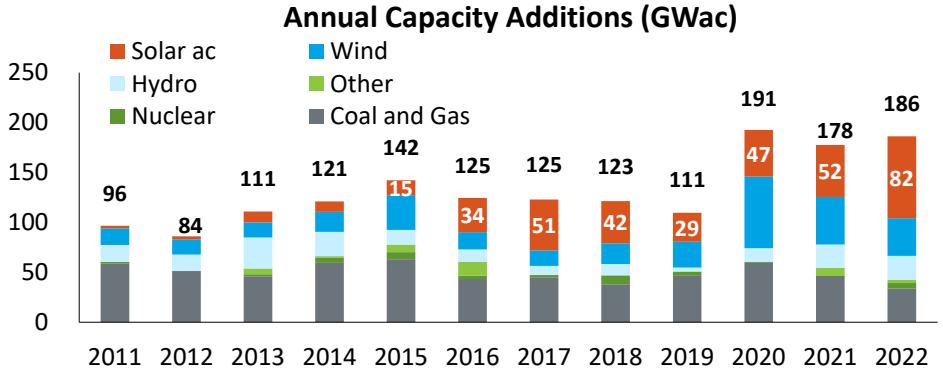
Sources: BNEF, Global PV Market Outlook, 11/25/21, 3/1/22, 8/26/22, 2/28/23; Goldman Sachs, Americas Clean Technology: Solar 2021 Outlook, 01/09/22; Goldman Sachs, Americas Clean Technology: Solar, Assessing the Impact of Volatile Macro - Oil, Commodities & EU in Focus, Raise Demand View Thru 2025, 3/29/22; Goldman Sachs, America's Clean Technology: Solar, 2023 Outlook, 12/18/22; NREL, Solar Industry Update, 1/11/22, 4/26/22, 10/27/22, 4/27/23; Solar Power Europe, Global Market Outlook For Solar Power 2021-2025, 7/20/21; SolarPower Europe, Global Market Outlook For Solar Power: 2022-2026, 5/22.

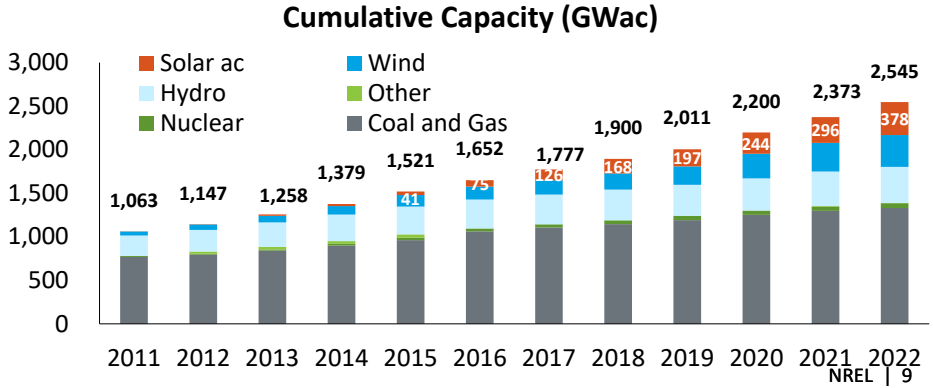
Chinese Generation Capacity Additions by Source

Note: Based on new information, annual and cumulative solar values now assume that China's National Energy Administration (NEA) reports distributed PV in direct current terms and utility-scale PV in alternating current terms.

Sources: China NEA (1/18/23); IEA, National Survey Report of PV Power Applications in China, 2021.

- In 2022, solar contributed 44% to new generation capacity in China (97 GWdc/82 GWac) and 15% of cumulative capacity (462 GWdc/378 GWac).
  - The record for annual solar installed was broken for the second year in a row.
  - In 2022, 61% of new PV was distributed, 39% was utility scale.
  - Wind and solar accounted for 64% of capacity installed in 2022, and together they have constituted the most capacity installed for 7 years running.
  - Annual coal and gas additions fell for the second year in a row, reaching the lowest level in more than a decade.
- Renewable sources continue to capture a larger share of China's growing electric capacity.
  - In 2011, renewables made up 26% of 1.1 TW of total capacity.
  - In 2022, renewables made up 45% of 2.5 TW of total capacity.



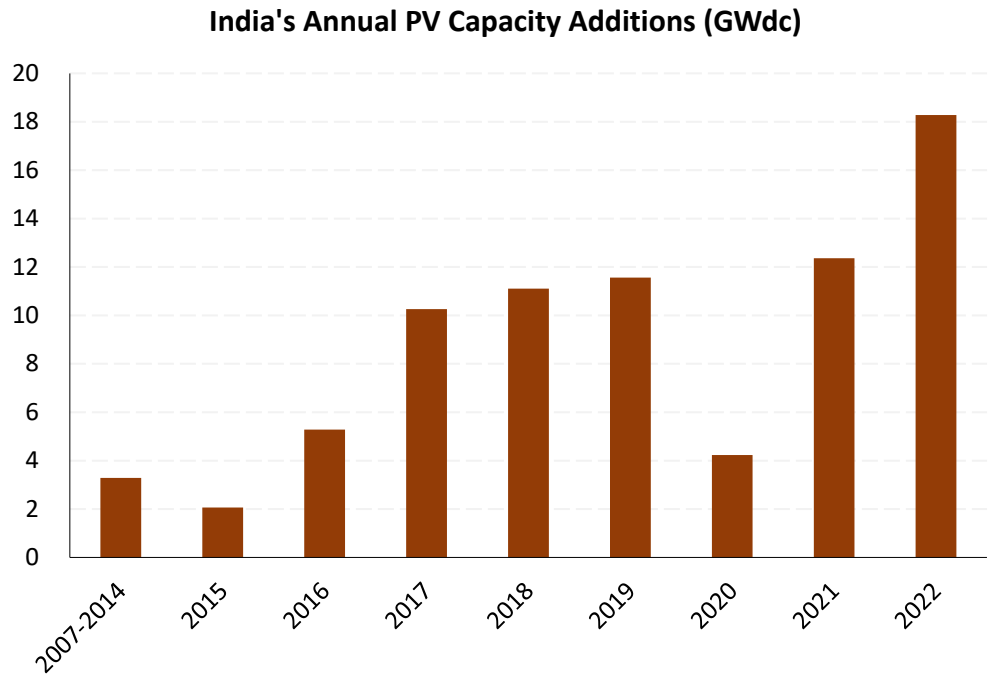


Chinese Market Update

Sources: BloombergNEF, China Will Produce 430 GW of Modules in 2023 Industry Says, 3/8/23; BloombergNEF, China's Rooftops Are Becoming the Key to the World's Solar Boom, 3/31/23; China NEA (1/18/23); PV Tech (3/28/23, 3/30/23).

- Although China has continued to deploy PV rapidly, headwinds include high supply chain prices, constraints on land development, and lack of transmission from remote PV projects to densely populated areas.
- One solution is more rooftop PV—for the second year, China installed more distributed PV than utility-scale PV in 2022.
  - Distributed PV now constitutes about 40% of total PV capacity.
  - The 50 GWac of distributed PV installed in 2022 eclipsed the total renewable energy installed by any other country; about 1 of every 4 modules installed globally in 2022 was on a Chinese rooftop.
  - Distributed PV surged in 2021 and 2022 owing to subsidies, lower sensitivity to module price, high electricity rates charged to businesses along with power outages and pressure to decarbonize, and a bulk-buying program for local governments.
  - Challenges going forward include strains from excess PV generation on distribution grids—which is stimulating time-of-use rate structures—expiration of national subsidies in 2021, and higher costs due to requiring storage paired with PV in most provinces.
- Another solution is funneling utility-scale PV onto low-value lands—the Chinese government is promoting deployment in desert areas and oil and coal fields while discouraging deployment on farmlands and areas with ecological or cultural value.

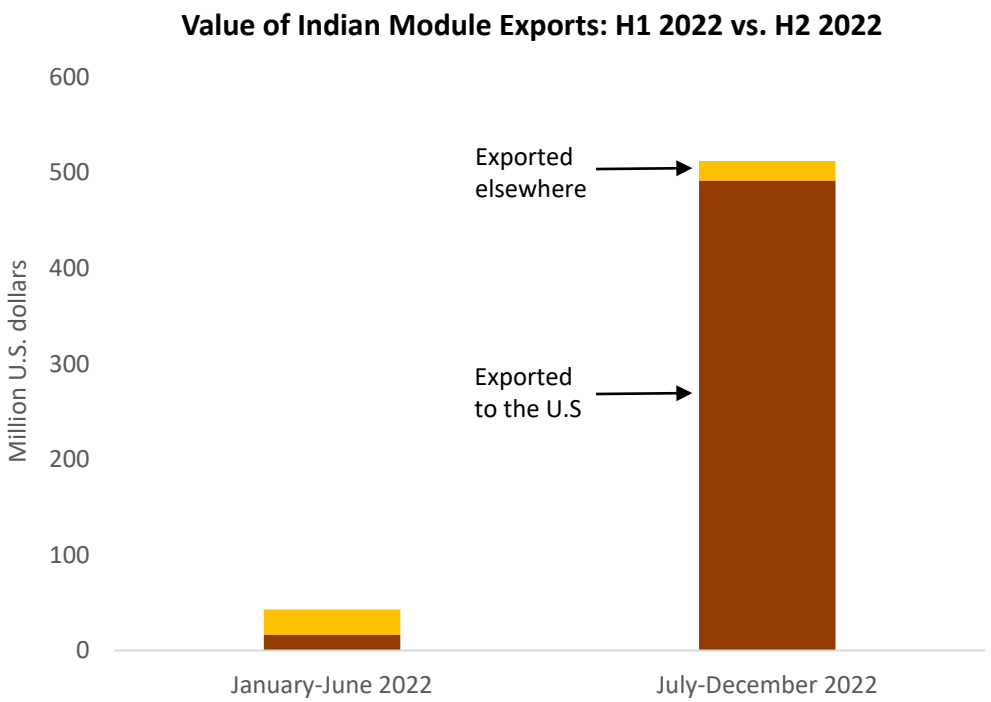
Indian Market Update



- India's annual PV additions achieved a record in 2022 at 13 GWac (18 GWdc), up 27% from 2021.
  - Large-scale projects increased 33% from 2021 and made up 87% of new 2022 PV capacity.
  - Rooftop projects decreased 4% from 2021 and made up 13% of new 2022 PV capacity.
  - PV made up a record 82% of total capacity additions and totaled 63 GWac at year end.
- Large project costs increased 7.3% in 2022.
  - Costs increased for 10 consecutive quarters mainly owing to higher module prices and supply constraints.
  - PV auction tariffs rose for the first time in 2022, primarily because of the higher equipment costs and higher financing costs.
- At year end, 58 GWac of large projects were in the pipeline, with another 51 GWac pending auction.

Sources: BNEF, 1Q 2023 Global PV Market Outlook, 2/28/23; BNEF, 1H 2023 India Renewables Market Outlook, 2/28/23; Mercom India Research, Q4 & Annual 2022 India Solar Market Update, 2/20/23; Mercom (2/28/23).

Indian Market Update



- Indian module exports jumped more than tenfold between the first and second halves of 2022, with all the increase going to the United States.
  - India's module manufacturing capacity reached 40 GWdc in 2022, but only 10 GWdc was for modules of 500 Wdc or higher.
  - One projection shows India's module manufacturing capacity reaching 110 GWdc by 2026, which is 90 GWdc more than projected domestic installations in that year.
  - The U.S. module market yields higher profit margins than the Indian market.
  - Mid-year U.S. policies (UFLPA, AD/CVD investigation) contributed to demand for Indian modules.
  - Indian module exports to the U.S. totaled about 1.5–2.0 GWdc in 2022.
- Indian manufacturing is promoted through import barriers and incentives, but some Indian manufacturers are expanding without incentives.
- Indian manufacturers are reportedly considering U.S. module plants to benefit from IRA incentives.

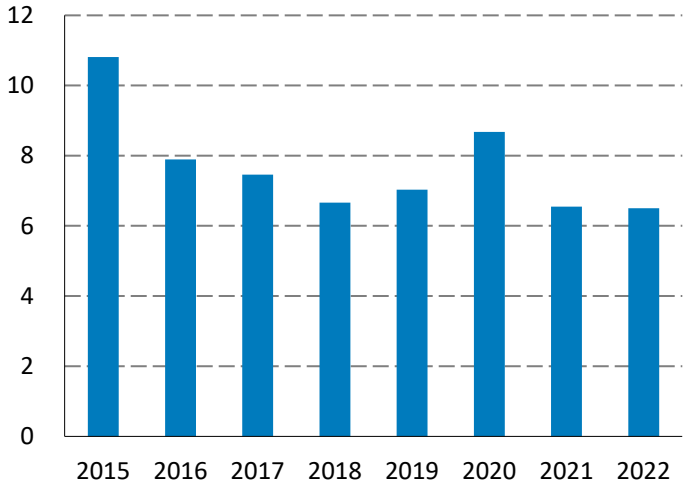
Sources: BNEF, 1H 2023 India Renewables Market Outlook, 2/28/23; BNEF, 1Q 2023 Global PV Market Outlook, 2/28/23; Goldman Sachs Equity Research, America's Clean Technology: Solar, 2023 Outlook, 12/18/22; JMK Research and Institute for Energy Economics & Financial Analysis, India's Photovoltaic Manufacturing Capacity Set to Surge, Mercom (3/10/23, 3/14/23); Mercom India Research, State of Solar PV Manufacturing in India, 3/23.

Japanese Market Update

- Japan installed 6.5 GWdc of PV in 2022, about the same as in 2021 as part of a mostly declining trend since the high in 2015.
- Cumulative capacity at the end of 2022 was about 85 GWdc.

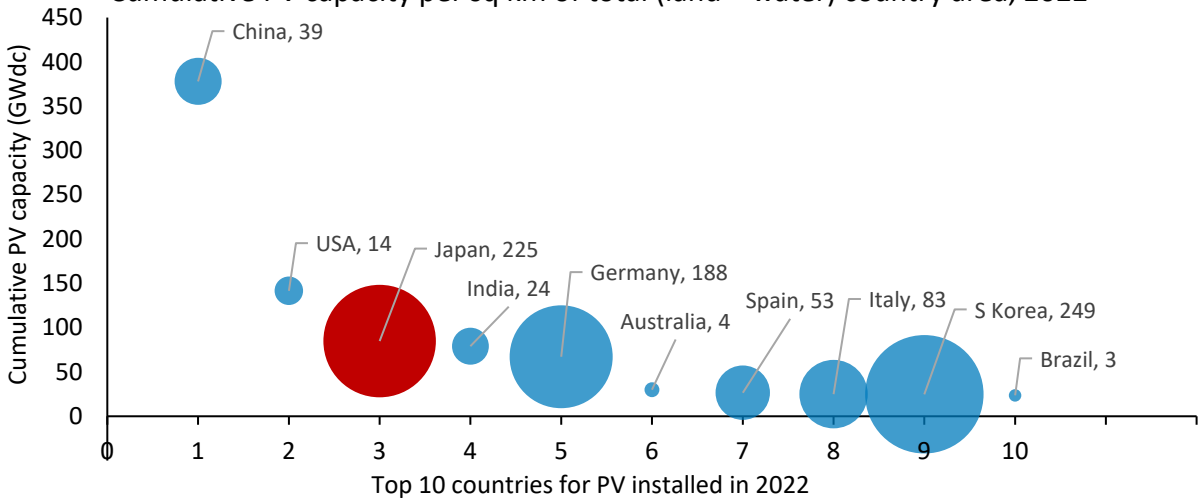
- Scarce land and decreasing feed-in tariff rates continue to constrain PV deployment, while goals require at least doubling PV capacity by 2030.
- Japan is experimenting with requiring PV on new buildings and with deploying agrivoltaics.
- Government subsidies stimulated an increase in corporate PPAs in 2021 (91 MWdc) and 2022 (228 MWdc), most of which were PV PPAs.

Japan's PV Capacity Additions (GWdc)



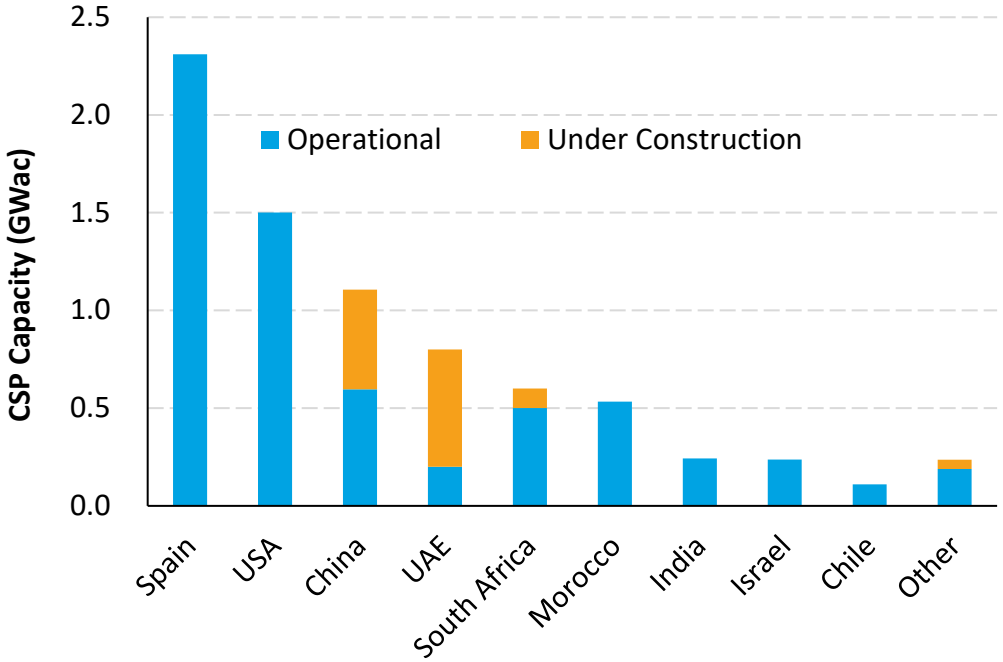
Japan's High PV Density

Cumulative PV capacity per sq km of total (land + water) country area, 2022



Sources: BloombergNEF, 1Q 2023 Global PV Market Outlook; IEA, National Survey Report of PV Power Applications in Japan, 2021; IEA, Snapshot of Global PV Markets: 2023; PV Magazine (3/21/23); U.S. Central Intelligence Agency, World Factbook.

Global CSP Capacity

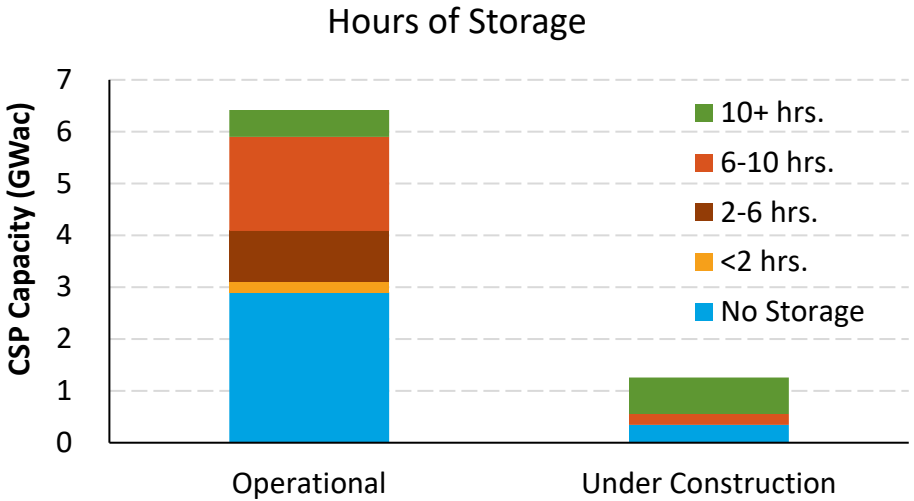


- At the end of 2022, global CSP capacity reached approximately 6.4 GW, with 1.3 GW under construction.
  - While no CSP projects were installed in 2022, the Noor facility in UAE added 100 MW of CSP in February 2023.
  - All Chinese CSP projects under construction are co-located with PV.
- There are an additional 3 GW of CSP projects under development in China, not included in these numbers.

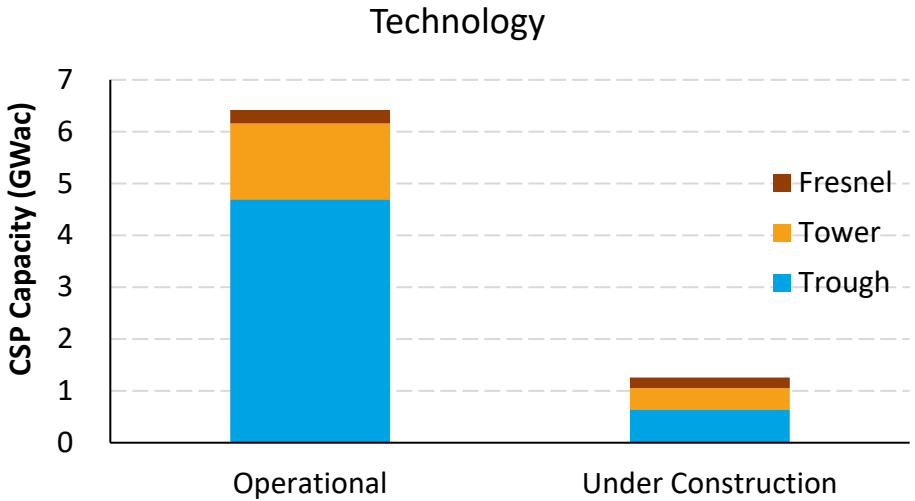
Sources: Richard Thonig, Alina Gilmanova & Johan Lilliestam. (2023). CSP.guru 2023-01-01 [Data set]. Zenodo.https://doi.org/10.5281/zenodo.1318151.

Global CSP Capacity

- Over half of CSP projects in operation have storage, with 36% of the capacity having 6 hours or more of storage.
- Projects under construction, on average, have storage, and longer hours of storage, than those currently in operation.

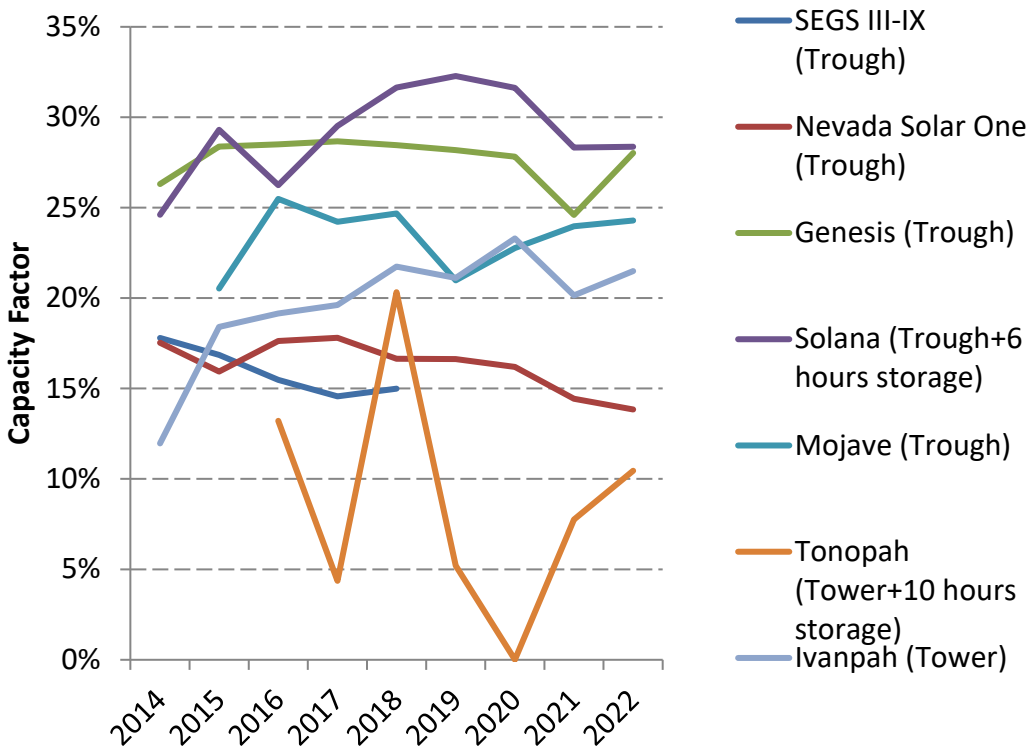


- 73% of current CSP capacity uses parabolic trough technology, compared to 51% of those under construction.



Sources: Richard Thonig, Alina Gilmanova & Johan Lilliestam. (2023). CSP.guru 2023-01-01 [Data set]. Zenodo.https://doi.org/10.5281/zenodo.1318151.

U.S. CSP Project Generation Performance, 2014–2022



- While it took a few years to optimize the operation of the five U.S. CSP plants brought online from 2013–2015, four of them now generally perform better than when they began operation.
  - Annual weather variation also caused some of the differences in annual production.
  - Tonopah continues to have, however produced power for seven months of the year in 2022 – the most since 2018. In September and October it reported an average capacity factor of 29%.
- Absolute capacity factor is not necessarily the best metric for performance as plants can be designed and operated differently.

Source: EIA, Form 923.

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- **In 2022, PV represented approximately 46% of new U.S. electric generation capacity, compared to 4% in 2010.**
  - Nearly 30 GWac of new installed capacity was either from renewable energy or battery technologies in 2022, a decline of 7 GWac compared to 2021.
- **Solar still represented only 9.0% of net summer capacity and 4.7% of annual generation in 2022.**
  - However, 16 states generated more than 5% of their electricity from solar, with California leading the way at 27.3%.
- **The United States installed 17.0 GWac (20.2 GWdc) of PV in 2022, ending the year with 110.1 GWac (140.6 GWdc) of cumulative PV installations.**
- **The United States installed approximately 14.1 GWh, 4.8 GWac of energy storage onto the electric grid in 2022, up 34% y/y.**

Recent Solar News (Congressional)

Repeal of the AD/CVD waiver/"bridge"

- On April 1, 2022, at the request of Auxin Solar, Commerce initiated country-wide circumvention inquiries on whether imports of c-Si PV cells and modules from Cambodia, Malaysia, Thailand, or Vietnam using parts and components from China are circumventing AD and CVD orders.
- On June 6, 2022, President Biden declared an emergency and authorized the temporary extension of time and duty (and deposit)-free importation of solar cells and modules from Southeast Asia for up to 24 months, over concerns the lack of panel supply would cause electric grid reliability issues.
- In December 2022, 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 was set to be due May 1, 2023, but has been extended to August 17th, 2023.
- In January 2023, a bipartisan group of lawmakers objected to the two-year waiver under the Congressional Review Act (CRA), which allows Congress to repeal executive decisions if a simple majority is reached and passed within 60 days.
- On April 18, 2023, a group of over 400 U.S. solar companies led by the Solar Energy Industries Association (SEIA) petitioned Congress to uphold the waiver. SEIA stated that if the CRA legislation passes, it will eliminate 30,000 U.S. solar jobs, including 4,000 in the manufacturing sector, cost U.S. solar companies over $1B in retroactive duties, and lead to the cancellation of 4 GW in planned projects.
- On April 28, 2023, the House passed the CRA (221-202) and the Senate passed it on May 3rd (56-41). On April 24, the WH promised to veto the legislation.

House debt ceiling bill:

- Repeals the ITC/PTC extension (including the domestic content, energy community, and low-income bonuses, as well as the labor requirements), and the 25D extension (including revoking the battery storage tax credit)
- Repeals the 48C increase (including the energy community and labor requirements) and repeals the MPTC
- Repeals the elective payment and transferability options
- Ultimately repeals or revisits 24 different tax incentives from IRA.

Sources: past 2022 Quarterly Solar Industry Updates, PV Tech in January and in April (18 and 19), WH press release, H.R. - Limit, Save, Grow Act of 2023

Recent Solar News

- On April 4, 2023, the White House released a Guidebook intended to help Tribal and indigenous communities navigate IRA opportunities. The Guidebook provides descriptions and eligibility information for Tribes to benefit from IRA grant, loan, and clean energy incentives. It also provides a brief summary of each program, key dates to watch out for, and important links for further information.
- On April 19, 2023, the EPA released its framework for the Greenhouse Gas Reduction Fund (GGRF), a $27B fund for clean energy projects targeting low-income and disadvantaged communities.
  - The framework outlines three grant competitions: the National Clean Investment Fund ($14B), the Clean Communities Investment Accelerator ($6B), and the Solar for All competition ($7B), which will provide 60 grants to States, Tribal governments, municipalities, and nonprofits.
  - The EPA invites feedback by May 12th on this framework, and also plans to hold six public listening sessions.
- Sunnova VPP loan guarantee
  - The U.S. Department of Energy Loan Program Office (LPO) announced a conditional commitment of up to $3B in a partial loan guarantee (i.e., a 90% guarantee of up to $3.3B) to Sunnova to support its Project Hestia. Certain conditions must still be satisfied before the DOE loan guarantee is issued, including finalization of definitive financing documents.
  - Sunnova's Project Hestia offers disadvantage individuals and communities better access to loans for solar installations, battery systems, or other Sunnova Adaptive Home™ technologies. To be eligible, the energy system must be outfitted with Sunnova's VPP-enabling software, which is designed to improve customer insights regarding their power usage and to facilitate demand response behavior.
  - The project is expected to provide loans for ~75,000-115,000 homeowners throughout the United States, with Sunnova targeting 20% of their loans to homeowners in Puerto Rico and at least 20% to customers with FICO credit scores of 680 or less. The ~568 MW, 25-year project is also estimated to created 3,400 job.
  - Sunnova has agreed to: provide monthly servicing reports supplemented by hardware and software deployment information to DOE, measure the reduction in greenhouse gases associated with Project Hestia, and deliver collateral pools that realize agreed criteria related to FICO distributions and certain concentrations of customers located in disadvantaged communities.

Sources: iratracker.org, WH press release, EPA press release, Solar Power World, LPO press release, Sunnova press release

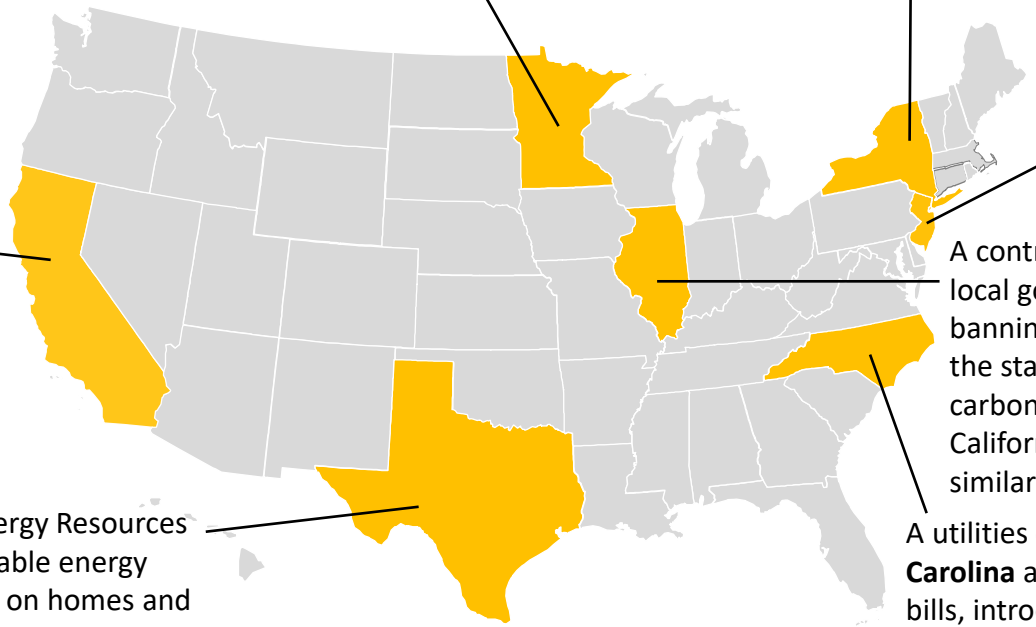
States: Q1 2023 Updates

A **New York** State Public Service Commission authorization provides $4.4 billion to fund 62 local transmission upgrades, which will enable 3.5 GW of renewable energy capacity. The upgrades are expected in the 2024–2030 timeframe.

A **Minnesota** law requires electric utilities to reach 100% carbon-free power by 2040. North Dakota, an exporter of coal-generated power, is considering suing Minnesota under the Constitution's Dormant Commerce Clause.

Three executive orders accelerate **New Jersey's** 100% zero-carbon electricity target by 15 years, to 2035. Legislation is required to implement the orders. A bill revising the state's renewable portfolio standard was introduced in 2022.

A **California** Public Utilities Commission (CPUC) order requires 4 GW of zero-carbon capacity by 2027, to support grid reliability and decarbonization, in addition to 11.5 GW ordered in 2021. CPUC also approved an integrated resource plan targeting 86 GW of new resources—mostly solar and batteries—by 2035.



A controversial **Illinois** law prevents local governments from limiting or banning solar and wind in support of the state's 2021 law targeting carbon-free power by 2045. California and New York have taken similar actions.

Texas' Aggregated Distributed Energy Resources Pilot Program is enabling controllable energy equipment (such as PV + storage) on homes and businesses to act as virtual power plants.

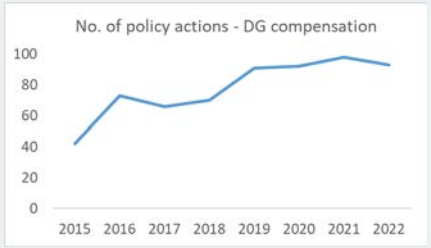
A utilities commission ruling in **North Carolina** adds rooftop PV minimum bills, introduces time-of-use rates, and incentivizes PV-plus-storage systems.

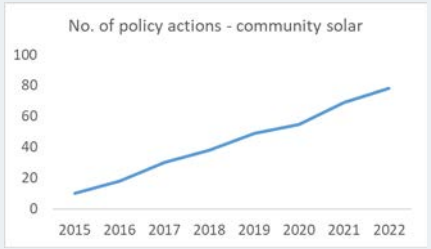
Source: Canary Media (1/27/23), Canary Media (2/24/23, 3/27/23), CPUC (2/23/23), Grist (9/15/21), Grist (3/2/23), Inside Climate News (2/27/23), New Jersey Legislature (8/8/22), Office of Governor Tim Walz (2/7/23), Politico (1/30/23), PV Magazine (2/15/23), PV Tech (2/20/23), RMI (3/6/23), State of New Jersey (2/15/23), Utility Dive (2/7/23)

States: 2022 Year-in-Review

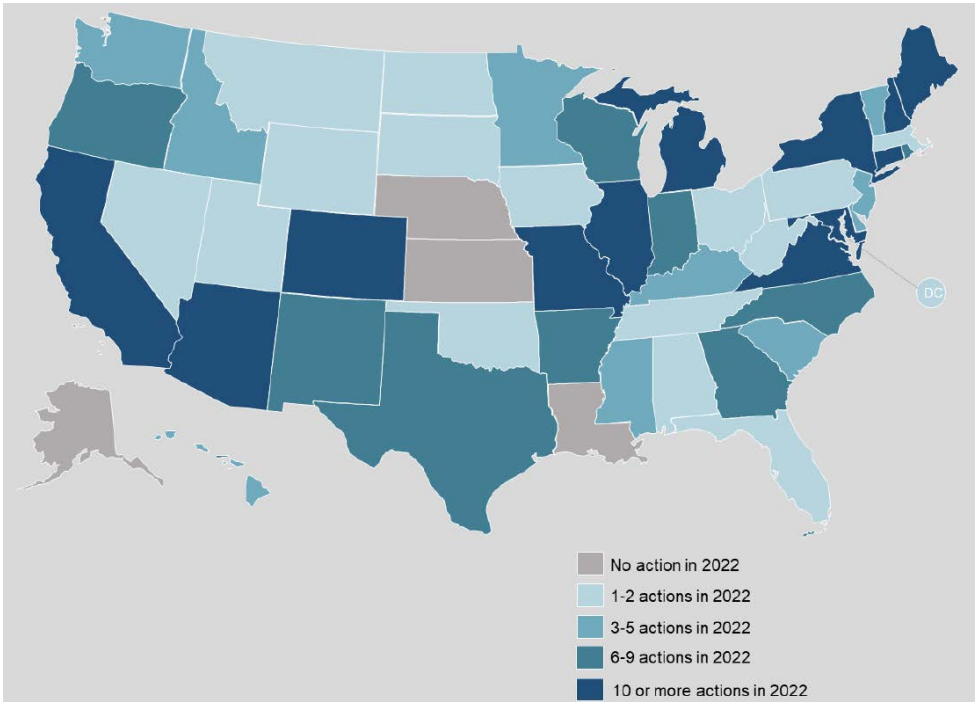
Top Solar Policy Trends of 2022

- Less use of traditional net metering
- More use of net billing and time-varying compensation
- More consideration of grid-access fees and minimum bills (with mixed results)
- Incorporation of PV provisions specific to low- and medium-income households
- Consideration of community solar programs
- Promotion of PV + battery systems
- Linking of labor requirements with PV programs
- Increased complexity of PV programs
- Use of iterative approaches to PV program design.





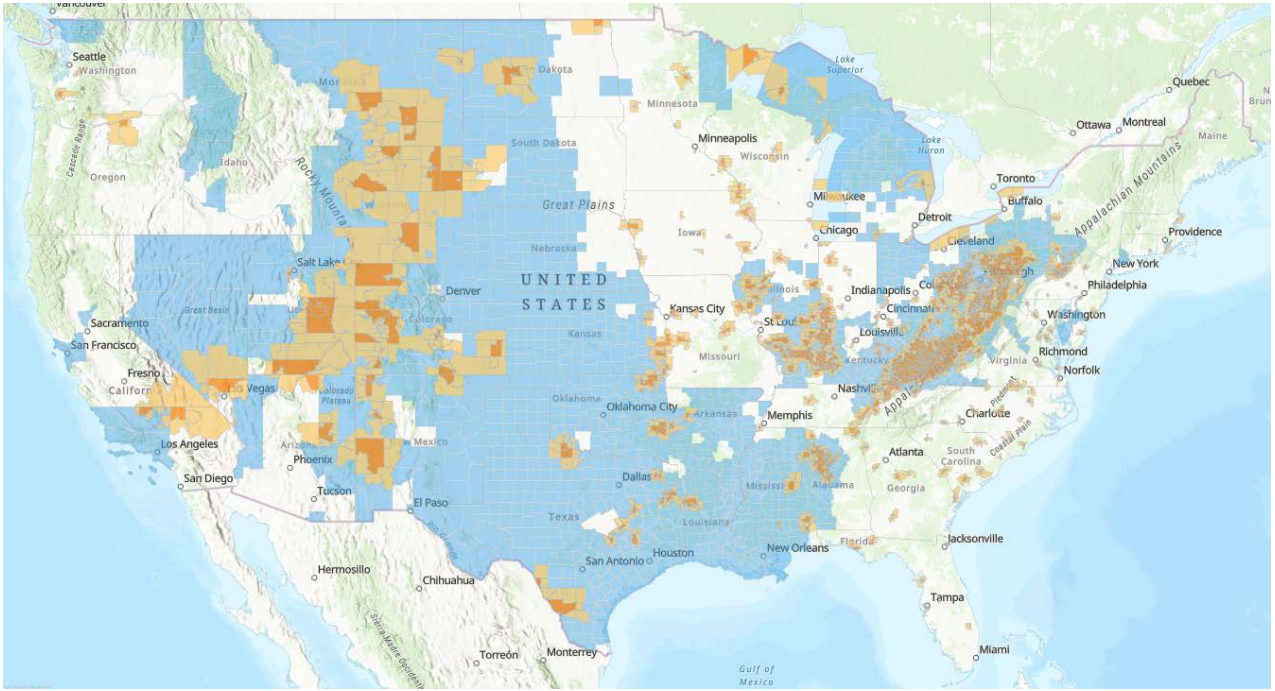
Number of solar policy and rate design actions in 2022



Source: North Carolina Clean Energy Technology Center, The 50 States of Solar: 2022 Policy Review and Q4 2022 Quarterly Report, January 2023. Map reproduced with permission.

New Guidance on the Energy Communities Bonus

Energy Communities Bonus Credit Program: a 10% increase to the Investment or Production Tax Credits (ITC/PTC) to brownfields, fossil fuel communities with high unemployment, and coal closure communities. Treasury released guidance on April 4th, including releasing a map hosted by the Interagency Working Group on Coal & Power Plant Communities & Economic Revitalization, DOE and IRS.



- Coal Closure Community
- Adjacent to a Coal Closure Community
- Metropolitan or Non-Metropolitan Statistics Areas that meet the Fossil Fuel Employment Threshold

Unemployment rates from 2022 are not yet available, so the areas are not yet confirmed as energy communities.

Not depicted:

- Brownfields
- Fossil fuel communities as determined based on tax revenue.

New Guidance on the Energy Communities Bonus

- **Brownfield Category:** Treasury clarified that any federal, state, territory, or federally recognized Indian tribal assessment process is sufficient to qualify, or the completion of an ASTM E1903 Phase II Environmental Site Assessment (Phase I for < 5 MW_{ac} sites) to confirm the presence of hazards and/or pollutants.
- **Statistical Area Category (a.k.a. Fossil Fuel Communities w/High Unemployment)**: Treasury clarified how metropolitan and non-metropolitan statistical areas were defined, how fossil fuel employment was defined, and how unemployment rates are calculated (and how those rates will be updated annually each May).
  - Treasury has invited public comments by May 4th addressing possible data sources, revenue categories, and procedures for determining eligibility based on Fossil Fuel Tax Revenue (instead of Fossil Fuel Employment).
- **Coal Closure Category:** Treasury clarified that census tracts are defined via the 2020 census, how a coal mine is deemed abandoned, how a coal-fired electric generating unit is deemed retired, and that "directly adjoining" is defined as a single point of contact.
- **Timing**:
  - For the PTC: the facility can located within an energy community for any part of the taxable year.
  - For the ITC: the facility must be within an energy community when it is placed in service.
  - Grandfather clause: If a facility begins construction within an energy community, the location can continue to be considered an energy community for the duration (for ITC or PTC).
- **Location:** ≥50% of a facility's nameplate capacity (dc for solar, MWh for storage, ac otherwise) must be within the boundaries of an energy community. Offshore projects can attribute their capacity to their land-based transmission/distribution equipment that is closest to the point of interconnection.

International Versions of IRA

Canada via Budget 2023

- Clean Electricity Investment Tax Credit: 15% *refundable* tax credit for eligible investments in non-emitting electricity generation (wind, solar, hydro, nuclear, abated natural gas), storage, and transmission equipment, lasts from 2024-2034, and includes labor incentives.
- Investment Tax Credit for Clean Technology Manufacturing: 30% *refundable* tax credit on the cost of investments in new machinery and equipment used to manufacture or process clean technologies, or extract/process/recycle critical minerals.
- "Canada must either meet this historic moment - this remarkable opportunity before us - or we will be left behind."
- These two tax credits are estimated to cost $25.7B + $11.1B = $36.8B CAD.

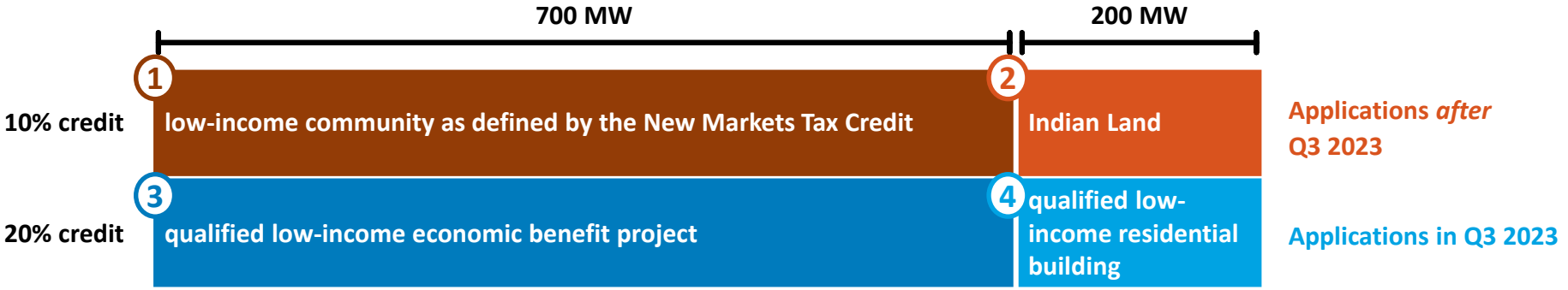
Australia via the National Reconstruction Fund

- $15B AUD fund to invest in 7 "priority areas" for the Australian economy:
  - Renewables and low-emission technologies were one category, as was mining and raw material processing.
  - $3B AUD was allocated for investing in: green metals; clean energy component manufacturing; hydrogen electrolyzers and fuel switching; and agricultural methane reduction and waste reduction.
  - $1B AUD was allocated for investment in advanced manufacturing.
- One of "the largest peacetime investments in Australian manufacturing capability."

Source: Chapter 3: A Made-In-Canada Plan: Affordable Energy, Good Jobs, and a Growing Clean Economy | Budget 2023, National Reconstruction Fund | Policies | Australian Labor Party (alp.org.au), Australia's Response To Inflation Reduction Act | TaiyangNews

New Guidance on the Low-Income Communities Bonus

Low-Income Communities Bonus Credit Program (48(e)), awards an upfront 10% or 20% bonus tax credit for a maximum of 1.8 GW_{dc} per year of solar projects ≤ 5 MW_{ac} in size. Treasury announced in February how the credits would be allocated in 2023:



Treasury and the IRS can reallocate excess capacity to any oversubscribed categories, with any unallocated capacity rolling over. Only the owner of the project can apply; projects cannot apply to more than one category; and projects placed in service prior to receiving an awarded an allocation are not eligible.

Treasury is still developing additional selection criteria, which may include 1) ownership by community-based organizations and mission-driven entities; 2) encourages new market participants; 3) provide substantial benefits to low-income communities and individuals marginalized from economic opportunities; and 4) have a high degree of commercial readiness.

Most of the guidance only applies to 2023 allocations and further guidance is still required in many key areas (to be provided later).

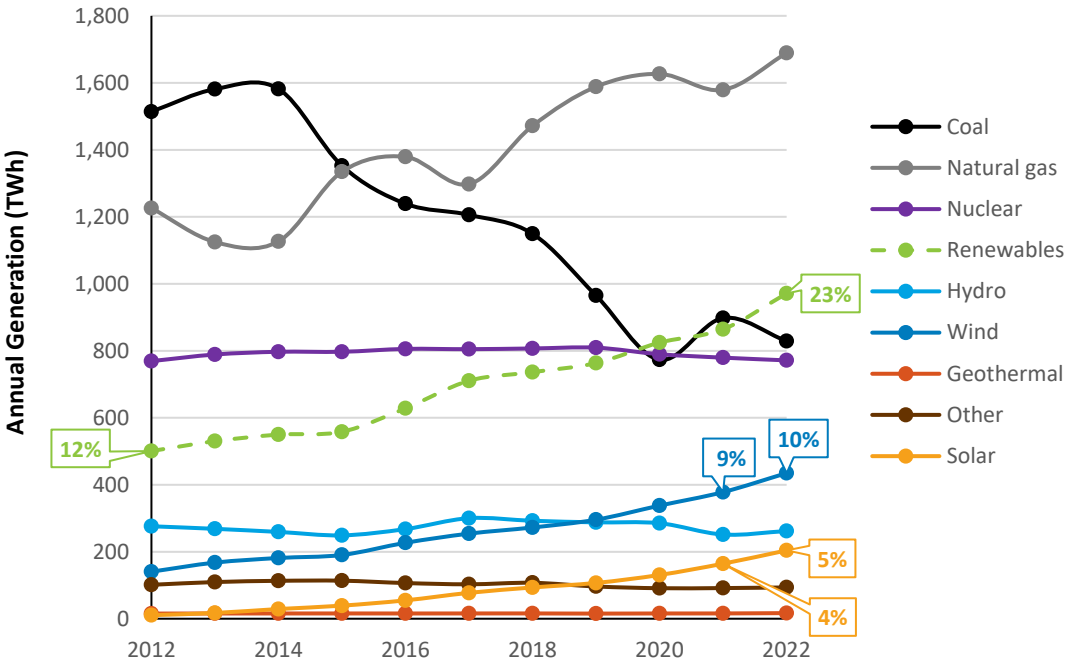
New Guidance Issued on 48C

On February 13, as mandated by law, the IRS issued guidance on the two Treasury tax credit programs with an allocation process.

- **Advanced Energy Project Credit (48C ITC)**, administered by DOE's MESC, awards an upfront 30% tax credit (if labor requirements are met) for capital investments made to purchase and commission an industrial or manufacturing facility.
  - 48C was originally established under the 2009 ARRA with $2.3B in funding and with a scope only covering green manufacturing.
  - IRA reestablished the program, expanding eligibility to include industrial facilities, and authorizing $10B in allocated tax credits, with $4B of the allocations going to projects in "energy communities" and that have not been allocated a credit before.

- **Notable 48C guidance issues on February 13th**
  - Selection will follow the standard DOE two-step FOA process of concept papers which received encourage/discourage letters, followed by review of a full application. The program will begin accepting concept papers on May 31, 2023, for a first round of $4 billion in credits, with approximately $1.6 billion reserved for projects in energy communities. Concept papers will be due no later than July 31, 2023.
  - The IRS will provide additional guidance May 31, 2023 on the technical review criteria that will be used to evaluate proposals. The IRS anticipates the criteria will include net impact on greenhouse gas reduction; community benefits of the project (community and labor engagement, as well as high quality, accessible jobs, and workforce pathways); the extent to which the proposed project addresses specific gaps, vulnerabilities, or risks to domestic clean energy production (including the risk associated with foreign involvement); and others.
  - Appendix A of the Notice provides further guidance by giving examples of property, product, and technology that are eligible and ineligible. Solar property is defined quite broadly.

U.S. Generation, 2012–2022



- The United States generated 4,300 terawatt-hours (or 4.3 petawatt-hours) of electric power last year.
- Energy generation from renewables continued its steady upward trend, as a result of increases in both wind and solar generation.
  - Solar and wind generation combined accounted for 15% of electric generation in 2022, up from 13% in 2021.
- The percentage of electricity generated by fossil fuels in the United States dropped from 69% in 2012 to 60% in 2022, while the percentage of electricity generated by renewable generation increased from 12% to 23% over the same period.
- In 2022, renewable energy facilities continued to produce more electricity than both nuclear and coal sources.
  - EIA attributed the decrease in coal-fired generation to several plants retiring and the remaining plants being less used. The decrease in nuclear generation was similarly the result of the Palisades nuclear power plant retiring.

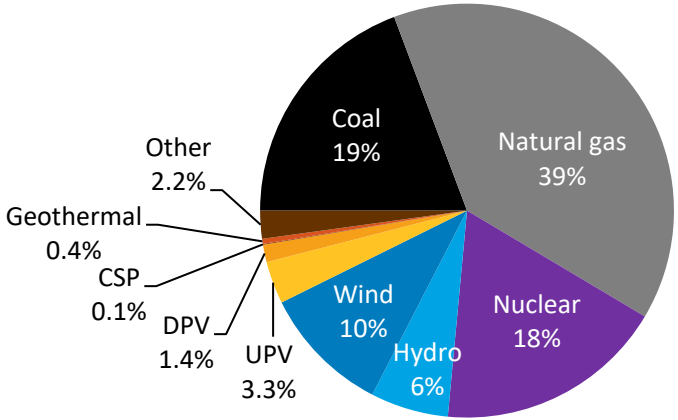
Sources: U.S. Energy Information Administration (EIA), "Electricity Data Browser." Accessed April 10, 2023; and a Today In Energy article (March 27, 2023).

2022 U.S. Generation and Capacity

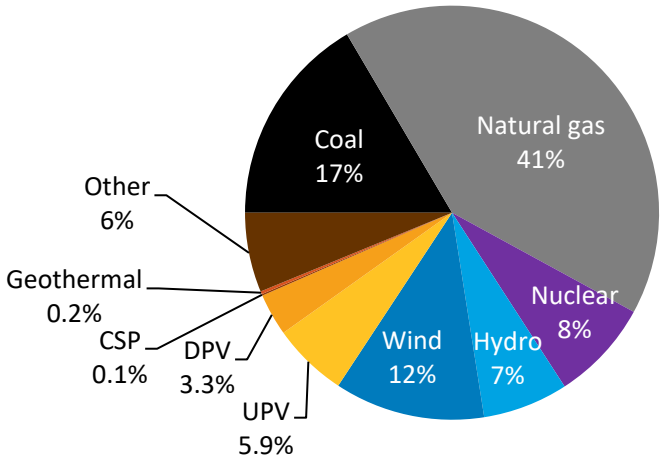
- Renewables are becoming an increasingly large part of the U.S. electric generation mix, representing 28% of capacity and 23% of generation in 2022.
  - Adding nuclear, non-carbon sources represented 36% of capacity and 41% of generation.

- Solar still represents a small but growing percentage of the U.S. electric generation mix.
  - In 2021, solar represented 9.0% of net summer capacity and 4.7% 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).

2022 U.S. Generation (Total 4,302 TWh)

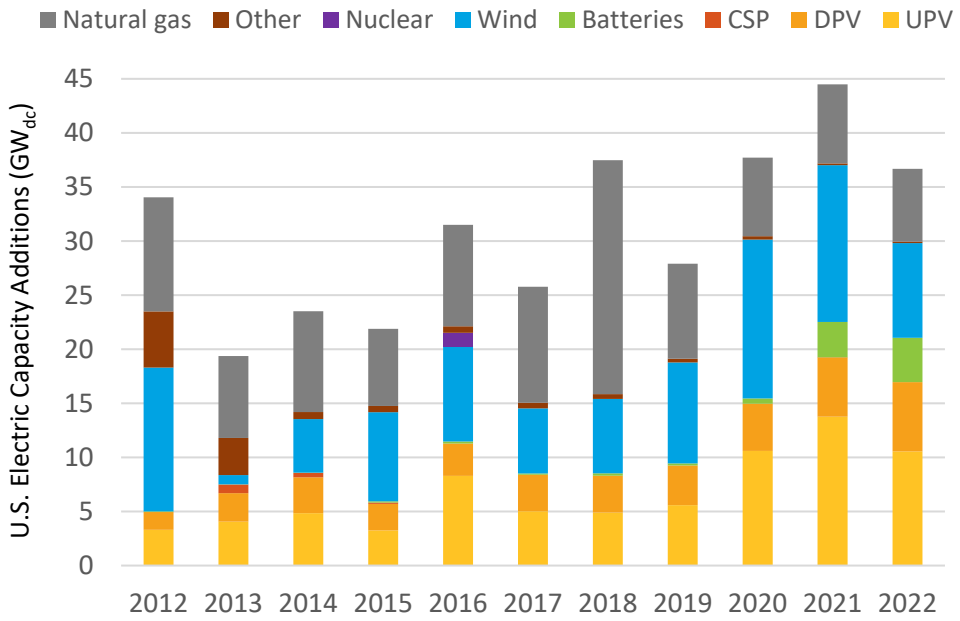


2022 U.S. Generation Capacity (Total 1.2 TW)



Sources: EIA, "Electric Power Monthly" Tables 6.1, 6.1A, February 2023, "Electricity Data Browser," April 10, 2023.

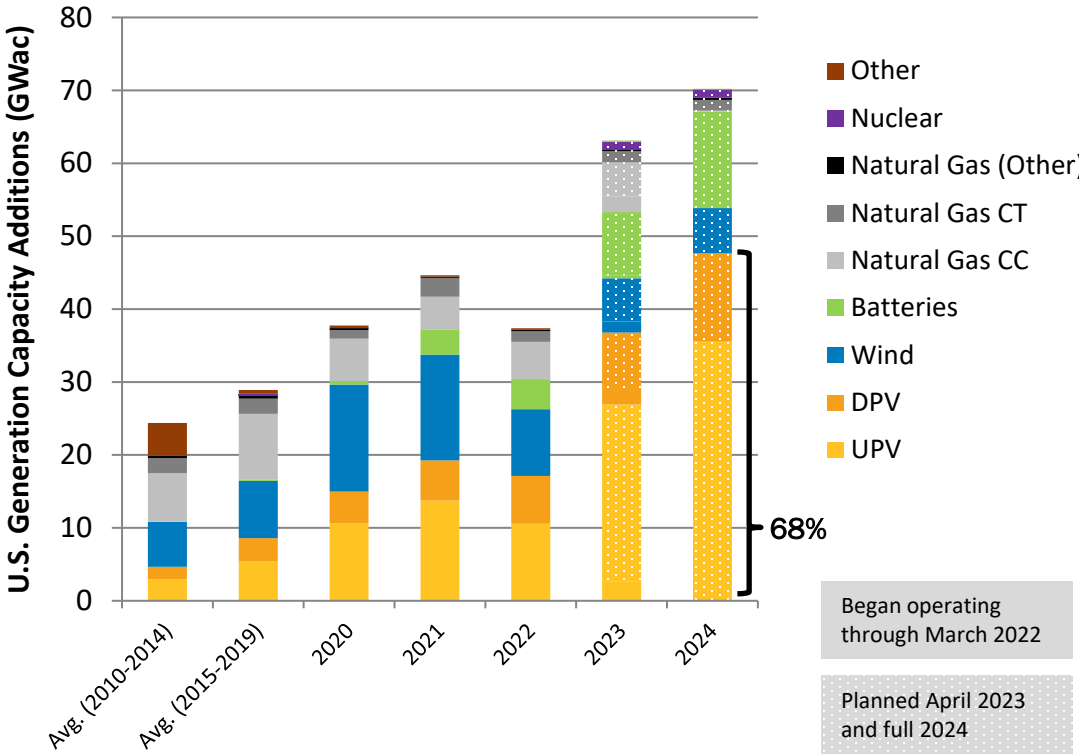
New U.S. Capacity Additions, 2012–2022



- In 2022, PV represented approximately 46% of new U.S. electric generation capacity (29% UPV, 17% DPV), compared to 15% in 2012.
  - Wind represented 24% of added capacity and batteries an additional 11%, for a total of 81% of capacity additions from those three technologies.
- Nearly 30 GW_{ac} of new installed capacity was either from renewable energy or battery technologies in 2022, a decline of 7 GW_{ac} compared to 2021.
  - Both solar and wind installations declined in 2022, although solar installations still nearly doubled that of wind.
  - Only battery installations grew from 3.3 to 4.1 GW_{ac} in 2022.

Note: "Other" includes coal, geothermal, landfill gas, biomass and petroleum.
Sources: EIA, "Electric Power Monthly" Tables 6.1, 6.2B, 1.1, 1.1A; Forms 860M & 861M. April 2023. Today in Energy.

U.S. Generation Capacity Additions by Source: 2010–2022 and *Planned* 2023–2024

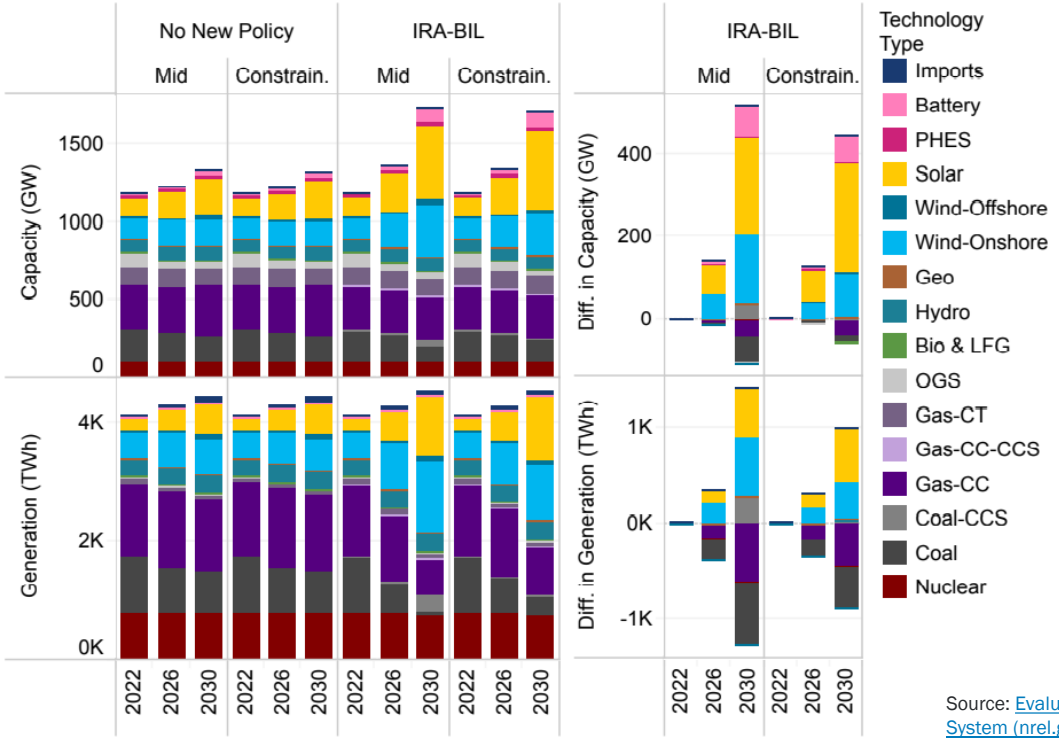


- EIA projects the percentage of U.S. electric capacity additions from solar will grow from 46% in 2022 (17 GWac) to 58% in 2023 (37 GW_{ac}), and 68% (47 GWac) in 2024.
  - Wind accounts for 12% and batteries 14%, and nuclear 2% of estimated capacity in 2023; in 2024 those percentages are 9%, 19%, and 2%, respectively.
  - Natural gas accounts for the remaining 13% in 2023.
- Over the next two years, EIA projects there will be nearly 100 GWac of capacity additions from wind and solar alone.
- Wood Mackenzie/SEIA projects 26-30 GW_{dc} of solar installations in 2023 and 30-36 GW_{dc} in 2024, depending both on favorable supply chain conditions (both domestic and international) as well as the ability to optimize the Inflation Reduction Act bonus credits.
  - Over the next five years, Wood Mackenzie/SEIA projects about 20 GWdc upside or downside relative to their base case as a result of these factors.

Sources: EIA Form 860M/Preliminary Monthly Electric Generator Inventory ("Planned" and "Operating") and EIA Short-term Energy Outlook Table 7e, downloaded April 25, 2023; Wood Mackenzie and SEIA US Solar Market Insight Full Report 2022 Year in Review, Mar 2023.

NREL Report on Projected BIL + IRA Impacts

Using ReEDS (the Regional Energy Deployment System), a team at NREL looked at the impact of IRA + BIL on the contiguous U.S. power sector from 2023 to 2030. They found:

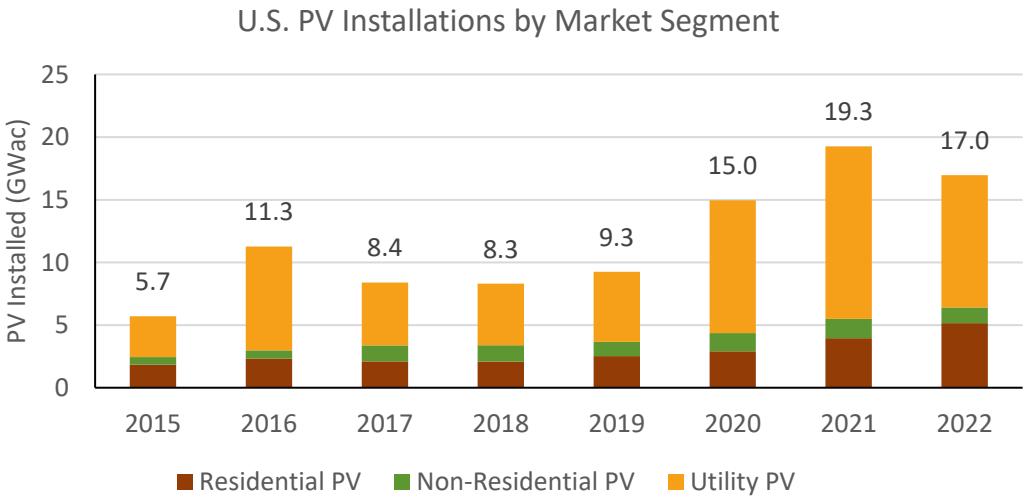


- Clean electricity could grow from 41% of total generation in 2022, to 71-90% by 2030.
  - Without IRA+BIL, clean electricity would only account for 46-52% of the grid.
  - This is mainly the result of increased production from wind and solar, supplemented by battery storage and long-distance transmission.
- Annual power sector CO_2 emissions could decline by 72-91% below 2005 levels by 2030.
  - Estimated avoided climate damages range from $160B to $230B.
- IRA+BIL are estimated to lead to a net decrease in power system costs of $8B-$25B annually by 2030 or $50B-115B from 2023 to 2030.
- Annual average deployment rates for wind and solar combined range from 44 GW/yr–93 GW/yr.

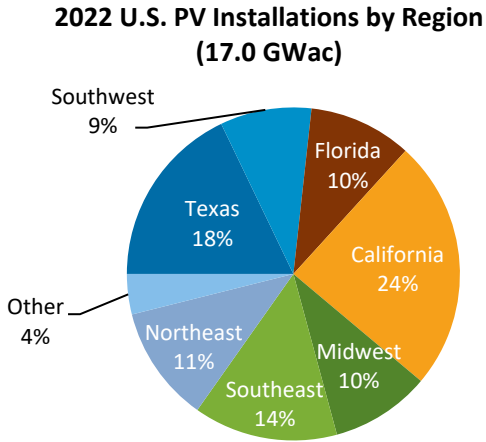
Source: Evaluating Impacts of the Inflation Reduction Act and Bipartisan Infrastructure Law on the U.S. Power System (nrel.gov)

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

- The United States installed 17.0 GWac of PV in 2022—down 12% y/y.
  - Residential (5.2 GWac), was up 30%, however C&I (1.3 GWac), and utility-scale PV (10.6 GWac) were down 19% and 23%, respectively, in 2022.



- Approximately 52% of U.S. PV capacity installed in 2022 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.
  - 20 states had more than 1 GWac of cumulative PV installations at the end of 2022 (Oregon achieved this distinction for the first time in 2022), and 29 states installed more than 100 MWac in 2022.



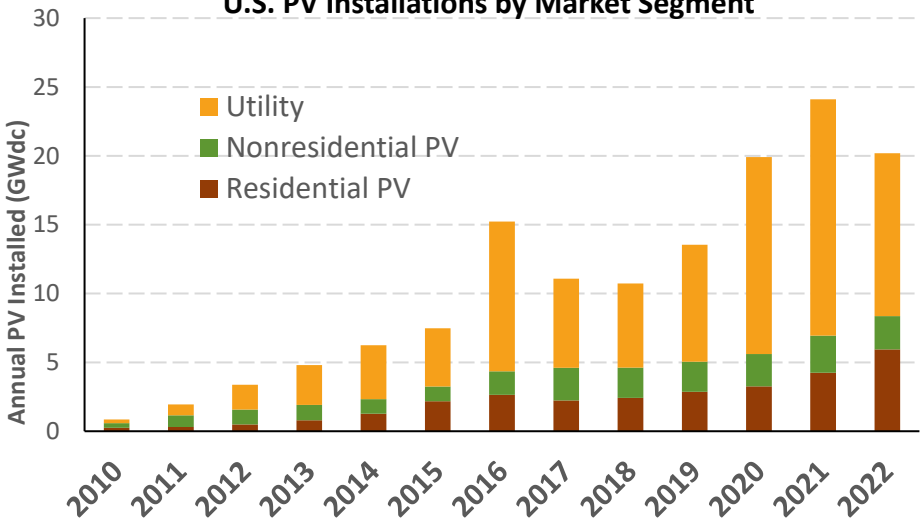
Note: EIA reports values in Wac which is standard for utilities. The solar industry has traditionally reported in Wdc.
Sources: EIA, "Electric Power Monthly," forms EIA-023, EIA-826, and EIA-861 (March 2023, April 2022, February 2021, February 2019).

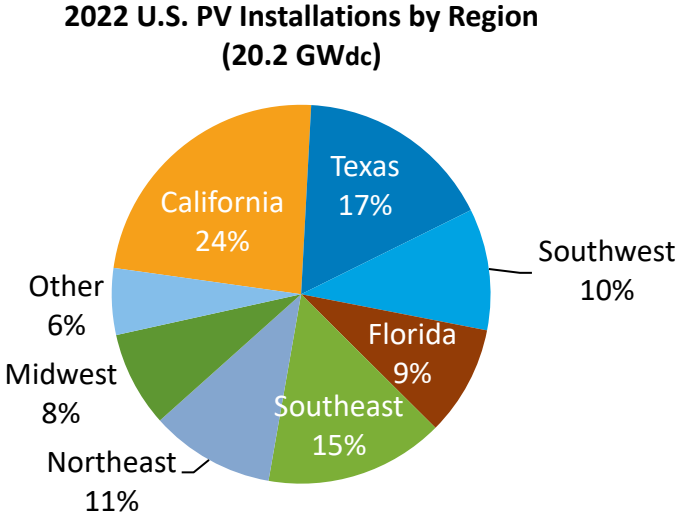
U.S. Installation Breakdown Annual: SEIA (GWdc)

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

- SEIA reports that the United States installed 20.2 GWdc of PV in 2022 (140.6 cumulative)—an annual decrease of 16% y/y.
  - 11.8 GWdc UPV (-31% y/y), 2.4 GWdc Non-residential (-10% y/y), and 5.9 GWdc Residential (40% y/y).
- Q4 2022 installations totaled 6.6 GWdc.

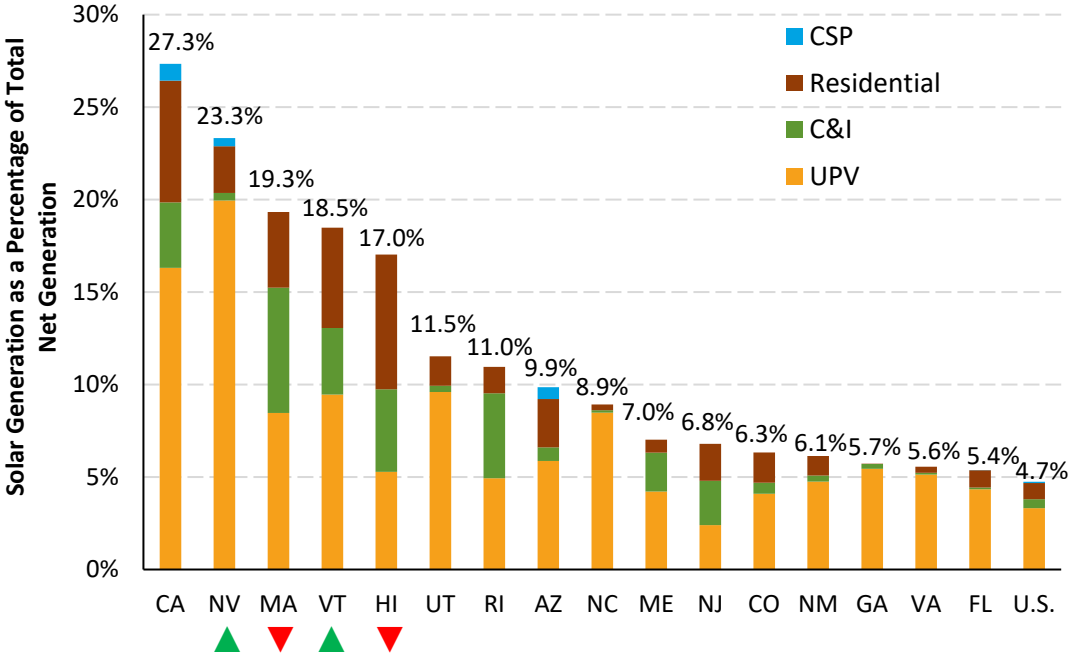
- In 2022, 50% of installed capacity occurred in California, Texas, and Florida, however 28 states installed more than 100 MW.





Sources: Wood Mackenzie/SEIA: U.S. Solar Market Insight: 2022 YIR.

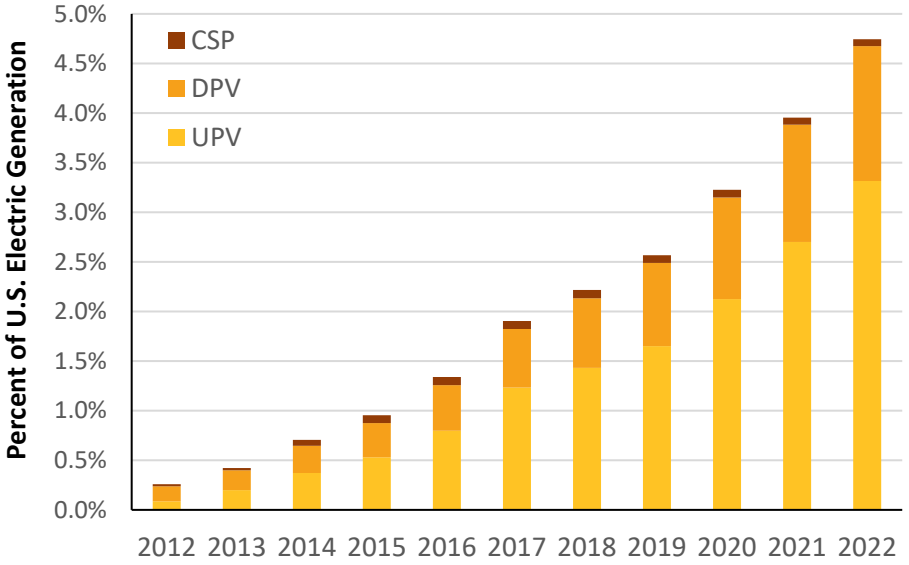
Solar Generation as a Percentage of Total Generation, 2022



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 March 31, 2023.

- During 2022, 16 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 relative to 2021.
  - Colorado, Maine, Georgia, Virginia, and Florida all recently surpassed 5% solar generation. Interestingly, despite having significant levels of deployment, Texas, at 4.8%, has yet to hit this threshold.
- Nationally, 4.7% 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.

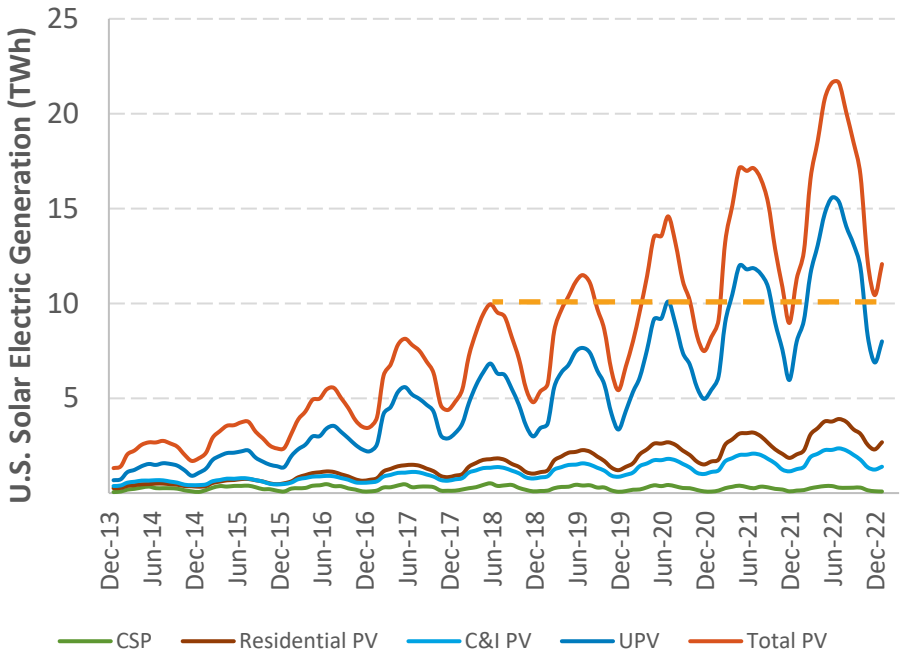
Solar Generation as a Percentage of Total Generation, 2012–2022



- In 2012, solar produced approximately 0.3% of total U.S. electric generation.
- By 2022, solar grew to 4.7% of electric generation.
  - 3.3% from utility-scale PV (UPV), a nearly 40-fold increase
  - 1.4% from distributed PV (DPV), a 9-fold increase
  - 0.1% from concentrating solar power (CSP), a 3-fold increase.

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.
Source: U.S. Energy Information Administration, "Electricity Data Browser." Accessed April 10, 2023.

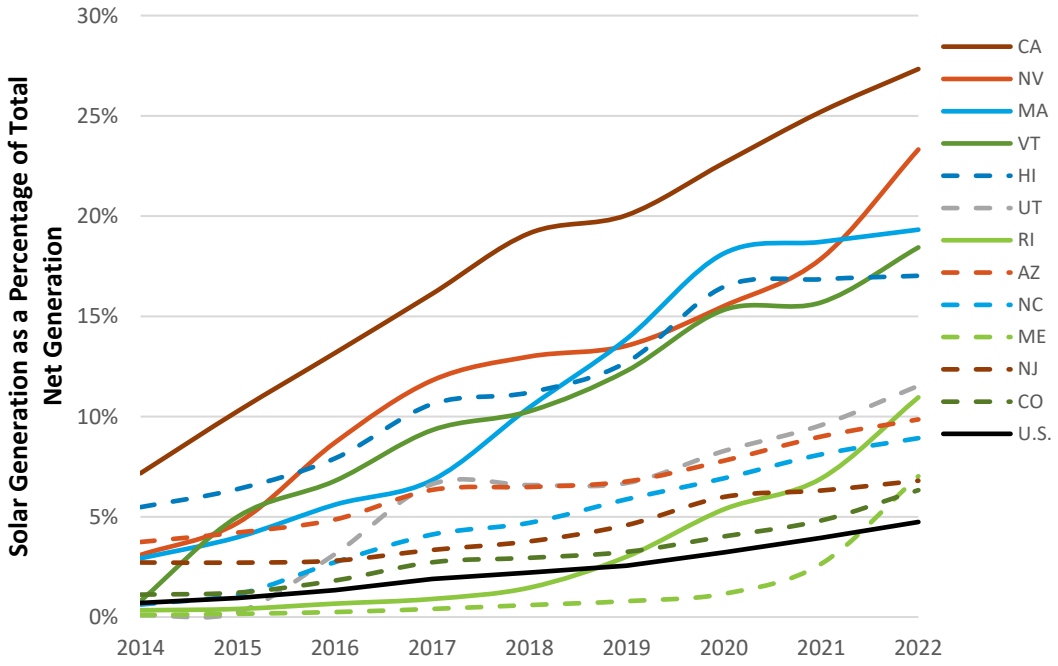
Monthly U.S. Solar Generation, 2014–2022



- Total peak monthly U.S. solar generation increased by a factor of 7.2 from 2014 to 2022.
  - U.S. electric generation in December 2022 (during the low seasonal period of electric generation) was above the peak solar production in 2018 (orange dotted line).
  - In April 2022, solar produced 5.8% of all U.S. electricity production, and produced over 5% of all U.S. electricity production in April, May, June, September, and October of 2022.
- Utility-scale solar electricity production (including PV and CSP technologies) dropped by 56% from its summer peak (June 2022) to its winter low (December 2022), 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 2022 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 2023).

Solar Generation as a Percentage of Total Generation, 2014–2022

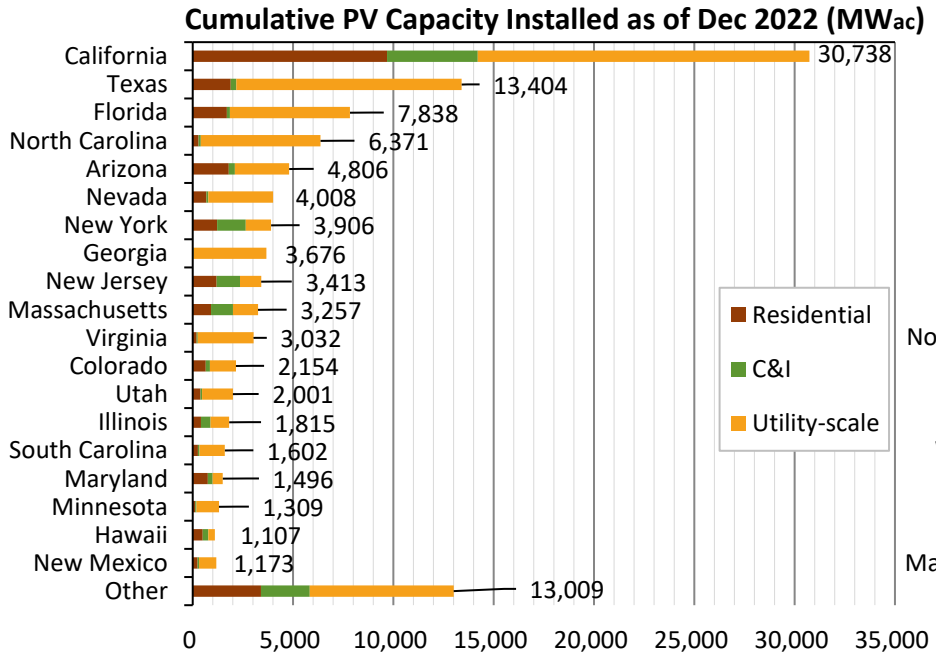


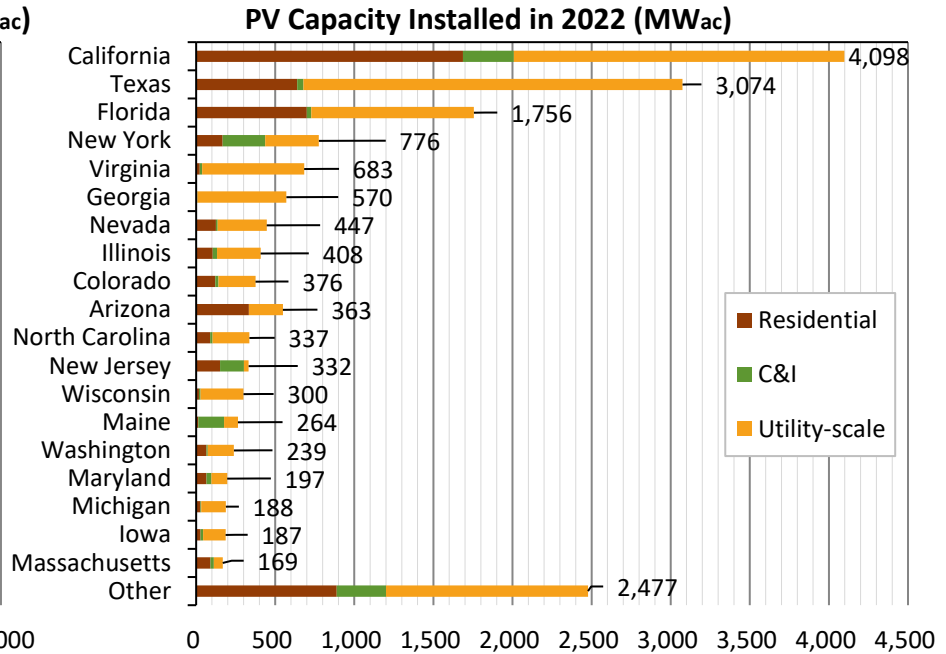
- From 2014 to 2022, leading solar deployment states greatly increased solar electricity penetration.
  - Rhode Island and Maine (light green) in particular have seen substantial growth since 2019.
- In the past 5 years, five states (solid lines) shifted over 9% of their electricity generation to solar 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 level, but it has still increased generation by 573% since 2014.

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 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 4, 2023.

U.S. Installation Breakdown by State

At the end of 2022, there were 110.1 GWac of solar PV systems in the United States, of which 70.6 GWac were utility-scale PV, 26.3 GWac were residential PV, and 13.2 GWac were C&I PV.



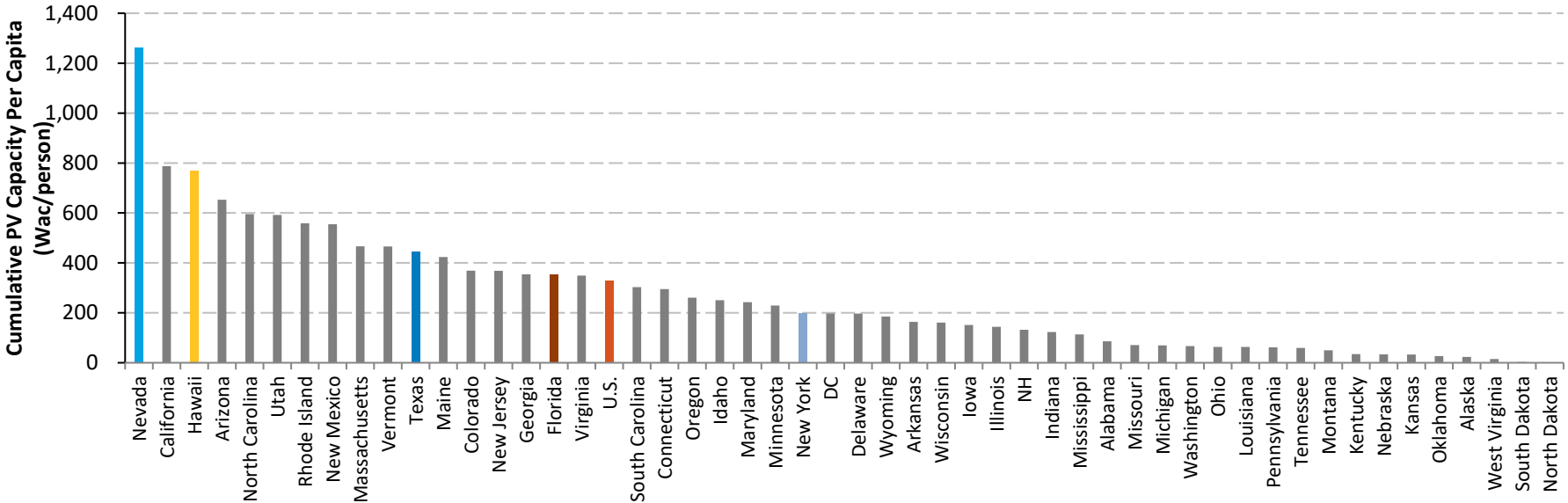


Note: EIA monthly data for 2022 are not final. Additionally, smaller utilities report information to EIA on a yearly basis, and therefore, a certain amount of solar data have not yet been reported. "Net Generation" includes DPV generation. Arizona's C&I installations in 2022 were net negative.

Sources: EIA, "Electric Power Monthly," forms EIA-023, EIA-826, and EIA-861 (February 2023, February 2022).

Cumulative U.S. PV Capacity Per Capita (2022)

- Some large states that ranked high in total cumulative capacity at the end of 2022, 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 #16, and New York to #25.
  - Conversely, Nevada and Hawaii, which ranked 6th and 19th in cumulative PV capacity, jump to 1st and 3rd in terms of PV watts per capita.



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 have not yet been reported. "Net Generation" includes DPV generation. Virginia's C&I installations in 2021 were net negative.

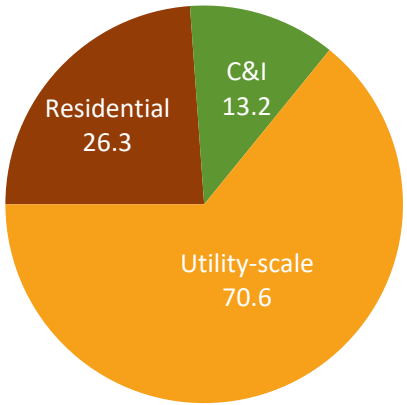
Sources: EIA, "Electric Power Monthly," forms EIA-023, EIA-826, and EIA-861 (February 2023); United States Census Bureau (2023).

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

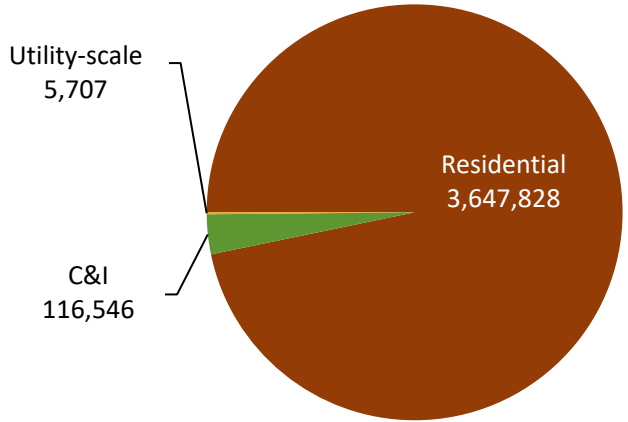
- At the end of 2022, there were 110.1 GWac of cumulative PV installations.
- EIA reports that at the end of 2022, 64% of U.S. installed PV capacity was from utility-scale PV systems.

- Despite representing only 24% of installed U.S. PV capacity at the end of 2022, 97% of PV systems—over 3.6 million systems—were residential applications.

Cumulative U.S. PV Installations as of December 2022 (110.2 GWac)

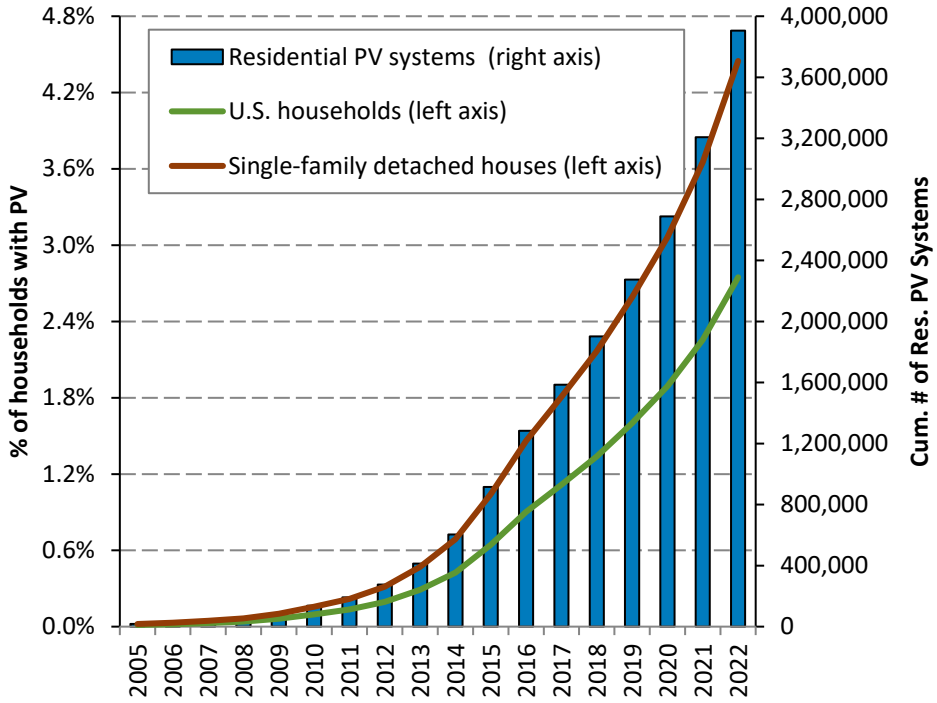


Cumulative U.S. PV Installations as of December 2022 (3.8 million systems)



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 2023).

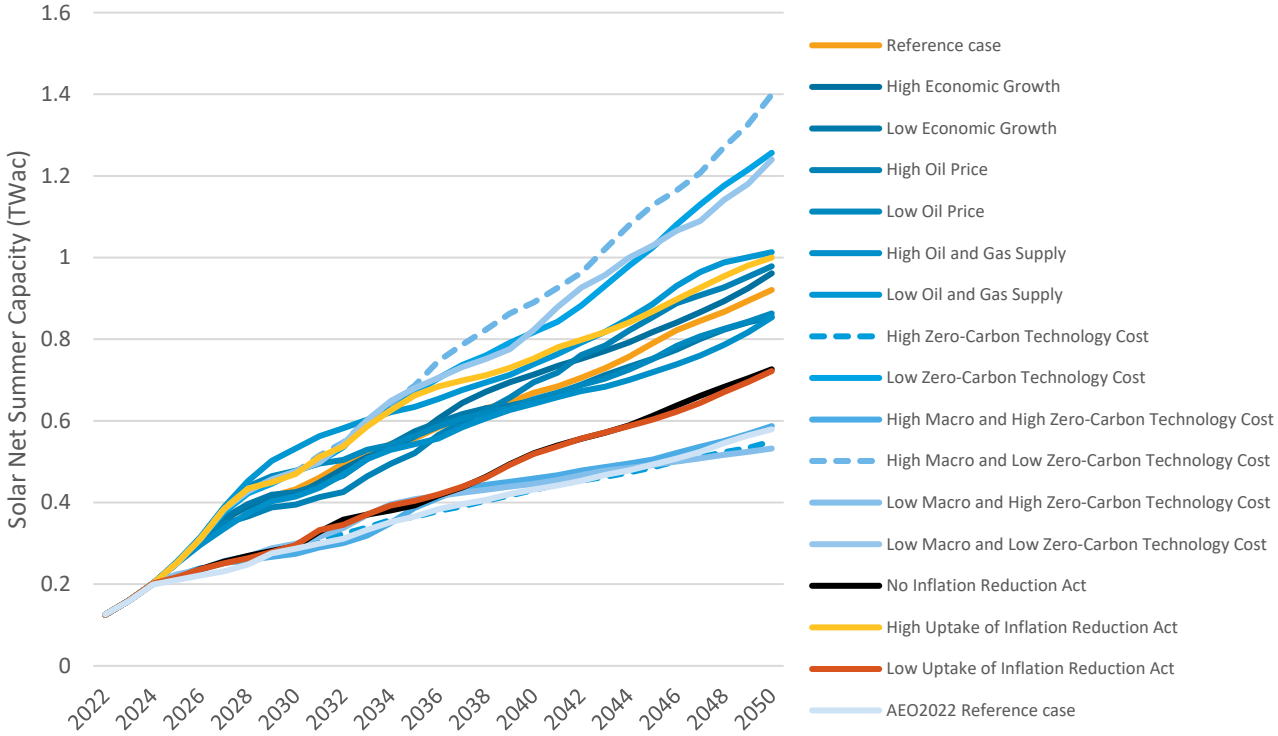
U.S. Residential PV Penetration



- Since 2005 when Congress passed the investment tax credit, the number of annually installed residential PV systems has grown by approximately 37% per year, or over 200X.
- At the end of 2022, there were approximately 3.9 million residential PV systems in the United States.
  - Still, only 2.7% of households own or lease a PV system (or 4.4% of households living in single-family detached structures).
  - However, solar penetration varies by location. Hawaii, California, and Arizona have residential systems on an estimated 33%, 20%, and 12% of households living in single-family detached structures.

Sources: Res. PV Installations: 2000-2009, IREC 2010 Solar Market Trends Report; 2010-2022, SEIA/Wood Mackenzie Solar Market Insight 2022 Year-in-Review; U.S. Households from U.S. Census Bureau.

AEO2023 Projections



EIA projects that total U.S. solar capacity (including both UPV and DPV) could range from 0.5 TWac to 1.4 TWac by 2050, across the 16 scenarios investigated.

EIA estimates that IRA could result in as much as 270 GWac more capacity by 2050 than there would be without the law.

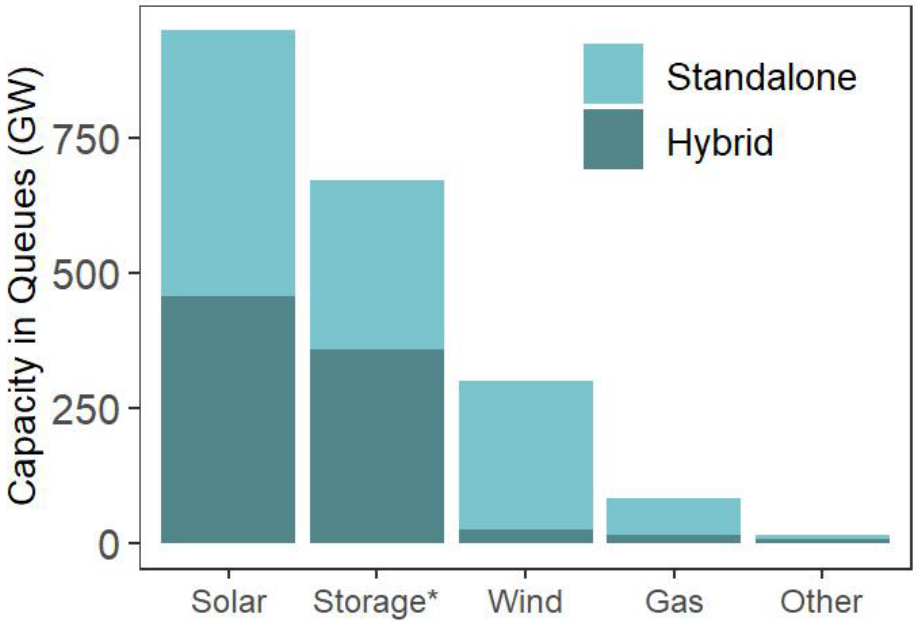
- The High Uptake case, which assumes that qualified projects receive the maximum bonus tax credits, projects 660 GWac of solar capacity by 2035, and 1 TWac by 2050.
- In the Reference case, the electric power sector solar is assumed to take the production tax credit and meet the labor requirements, growing to 560 GWac of solar capacity by 2035, and 920 GWac by 2050.
- Low Uptake case, which assumes most qualified projects only receive the base tax credit, projects only 400 GWac of solar capacity in 2035, and 720 GWac by 2050.
  - The SunShot Vision Study (released in 2012, projected 715 GWac of solar by 2050).
- No IRA case excludes energy-related IRA provisions and trends nearly identically to the Low Uptake case.

Note: "Other" includes coal, geothermal, landfill gas, biomass and petroleum.
Sources: EIA Today in Energy, Issues in Focus: Inflation Reduction Act Cases in AEO2023

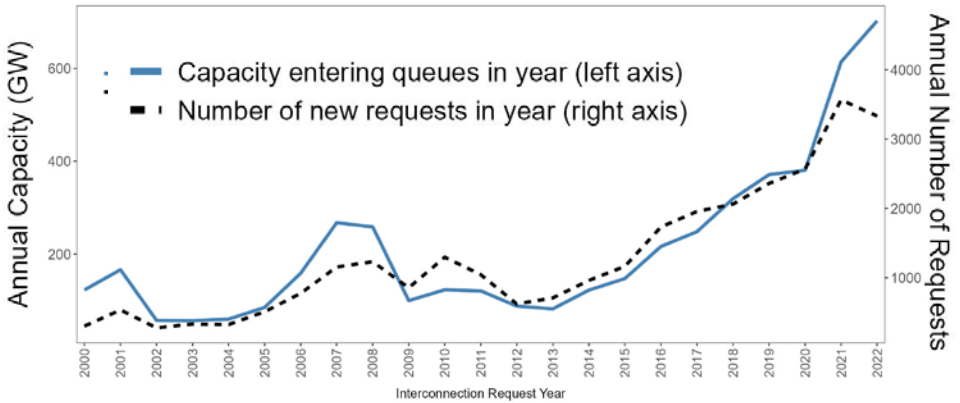
U.S. Transmission Interconnection Queues

- Substantial solar and storage capacity have been proposed in most regions of the United States.
  - Over 10,000 projects representing 1.35 TWac of generator capacity (1.26 TW of which is zero-carbon and 0.95 TW is solar) and 0.7 TWac of storage are seeking interconnection.
- Annual interconnection requests have increased dramatically—in terms of both number and capacity—since 2013; over 700 GWac was added in 2022 alone. Hybrids represent a significant portion of solar capacity.
- Only 14% of proposed solar projects entering queues from 2000 to 2017 have reached commercial operations (compared to 21% for all technologies).
- The average time spent in queues has increased over time. The typical projects built in 2022 took 5 years from interconnection request to commercial operation. This compares to 3 years in 2015 and less than 2 years in 2008.

Proposed Interconnections by Technology

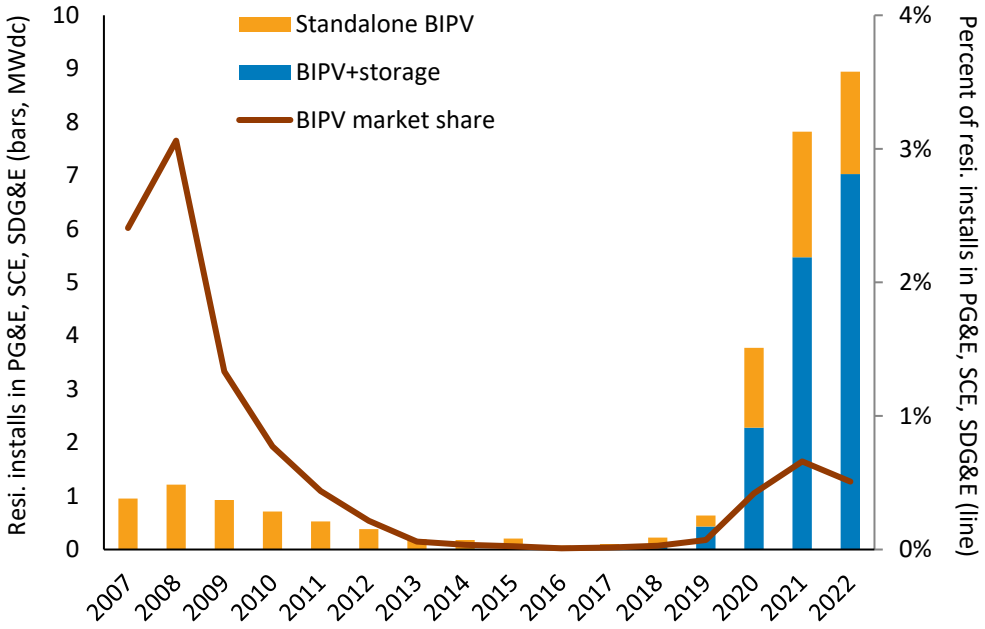


Interconnection Requests by Year



Source: LBNL, Queued Up: Characteristics of Power Plants Seeking Transmission Interconnection as of the End of 2022.

Residential Building-Integrated PV Rebound in California

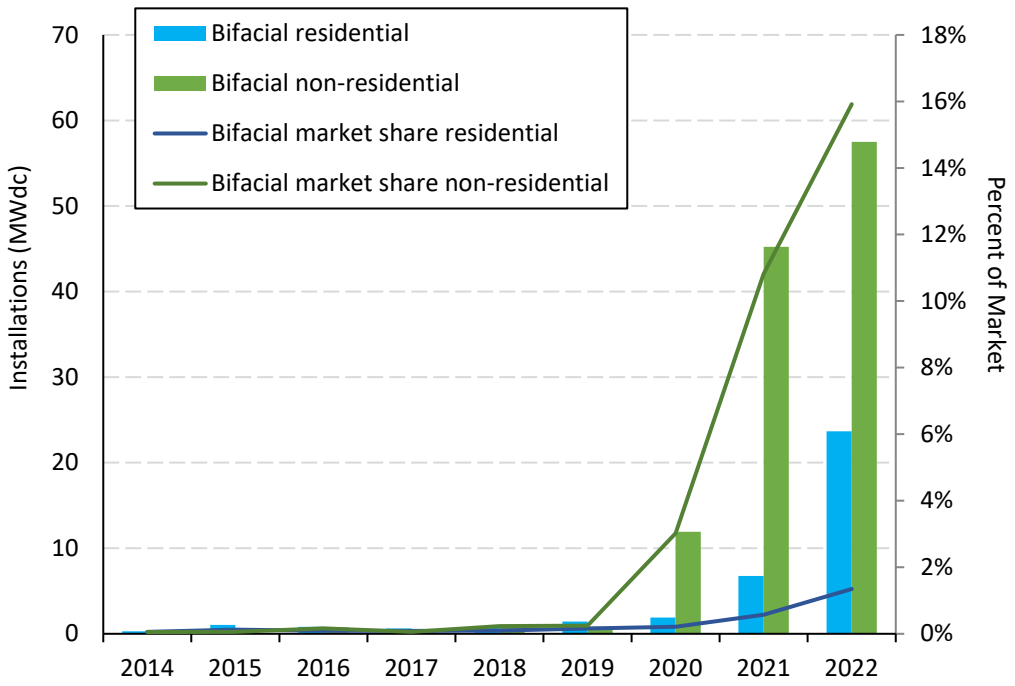


- In 2022, 8.9 MWdc of residential building-integrated photovoltaics (BIPV) was installed in the territories of California's investor-owned utilities.
  - After stagnating for more than a decade, residential BIPV averaged 140% growth in annual installations from 2020 through 2022.
  - During this period, 72% of the BIPV systems were coupled with energy storage.
  - Tesla installed 98% of BIPV capacity in 2021 and 94% in 2022.
  - GAF Energy—a spinoff of the major roofing manufacturer—began offering solar shingles in 2022 and captured 3% of the year's BIPV market share.
- Despite the recent growth, BIPV made up only 0.5%–0.7% of total residential PV installed in the California IOU territories in 2021 and 2022.
- About 3,000 Tesla BIPV "Solar Roofs" (~30 MWdc) have been installed nationwide since launching in 2016, constituting around 0.2% of the national residential PV market in 2021 and 2022.

Note: BIPV, as defined by the California Energy Commission's PV Module List, includes modules that are not rack mounted. The residential data described on this slide include standalone PV and PV-plus-storage systems installed in the territories of Pacific Gas & Electric (PG&E), Southern California Edison (SCE), and San Diego Gas & Electric (SDG&E).

Sources: Canary Media (3/30/23); CA NEM database (1/31/23); Fast Company (05/03/22); Forbes (04/19/21); Wood Mackenzie (3/30/23).

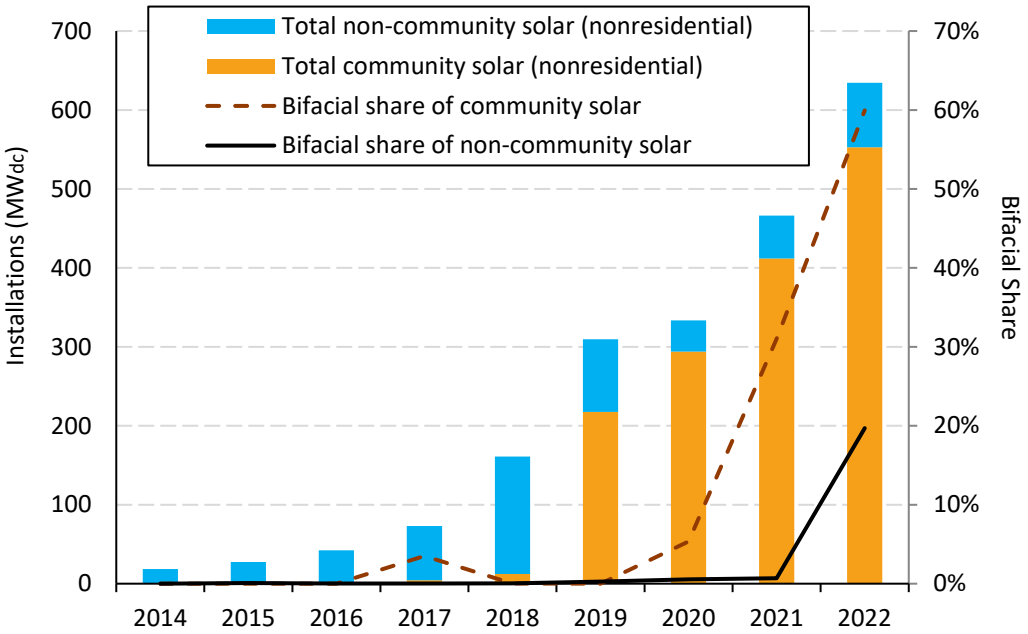
Bifacial Increase in California Distributed PV Installations



- In 2022, 81 MWdc of bifacial modules was installed in the California IOU territories—56% more than in 2021.
  - 24 MWdc (1.3%) of residential capacity was bifacial.
  - 58 MWdc (15.9%) of nonresidential capacity was bifacial.
- Ground-mount and flat-roof nonresidential PV installations can provide bifacial energy gain, but typical sloped residential rooftop installations do not provide bifacial gain.
- Installers may use bifacial modules to avoid tariff-related module costs: bifacial modules were exempted from Section 201 tariffs starting in June 2019.
- 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 (1/31/23); Solar Power World (11/16/21); DOE, Solar Futures Study

Bifacial Prevalence in New York's Community Solar



- New York's dataset reported a larger share of bifacial modules in 2022 than California's NEM database.
  - 4 MWdc (3.8%) of NY residential was bifacial.
  - 347 MWdc (54.8%) of NY nonresidential was bifacial.
- Differences between state datasets include project sizes and prevalence of community solar.
  - For all nonresidential capacity in 2022, the median was 39 kWdc in CA vs. 162 kWdc in NY, and the mean was 132 in CA vs. 1,431 in NY.
  - Community solar accounted for 87% of NY non-residential capacity in 2022 vs. 1% in CA.
  - 60% of NY community solar capacity (median project 420 kWdc) was bifacial in 2022 vs. 20% of other non-residential capacity (median project 39 kWdc).
  - The bifacial share varied by system size in CA, but less dramatically than in NY; for example, the share for systems ≥ 400 kWdc was 17% vs. 6% for systems < 40 kWdc.

Note: Bifacial modules are defined as having the term "bifacial" in the description field in the California Energy Commission's PV Module List. New York data are for projects supported by the New York State Energy Research and Development Authority (NYSERDA).
Source: CA NEM database (1/31/23); Solar Electric Programs Reported by NYSERDA (3/3/23); Wood Mackenzie & SEIA, US Solar Market Insight: 2022 Year in Review (3/23).

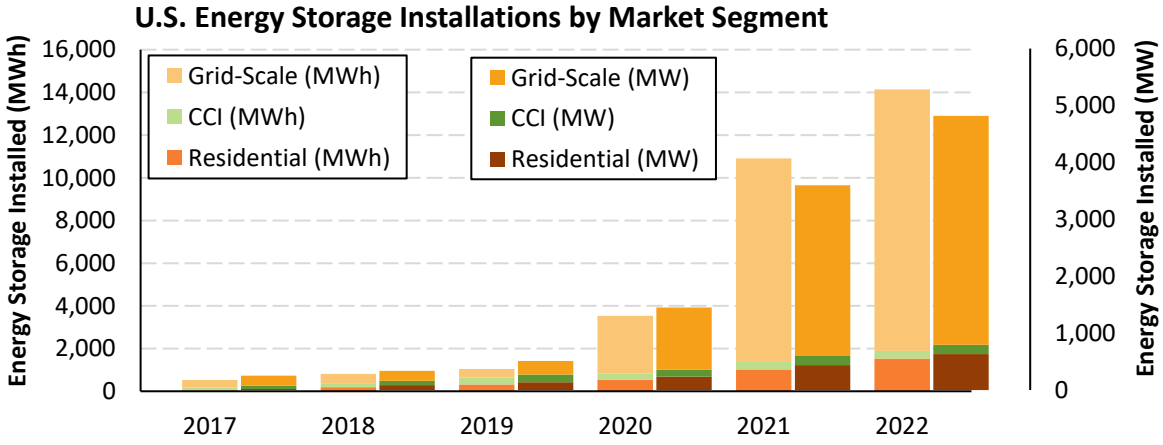
U.S. Energy Storage Installations by Market Segment (Energy Storage Association)

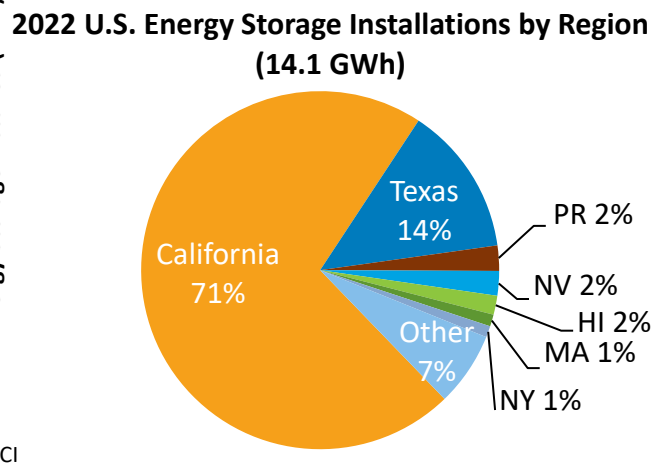
The United States installed approximately 14.1 GWh (4.8 GW_{ac}) of energy storage onto the electric grid in 2022, +34% (+30%) y/y as a result of high levels of residential deployment and grid-scale deployment.

- Grid-scale and residential storage installations were up 29% (34%) and 50% (44%) in 2022 y/y respectively.
- The increase came despite a 40% (34%) reduction deployment in Q4 2022, y/y.

California and Texas represented 85% of installed capacity in 2022, though the islands of Puerto Rico and Hawaii came in 3rd and 5th, respectively, installing around 300 MW of storage each.

- 12 states installed more than 40 MWh of storage in 2022.





Note: Front-of-the-meter refers to all projects deployed on the utility side of the meter, regardless of size or ownership. CCI refers to Community-scale, commercial and industrial.

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

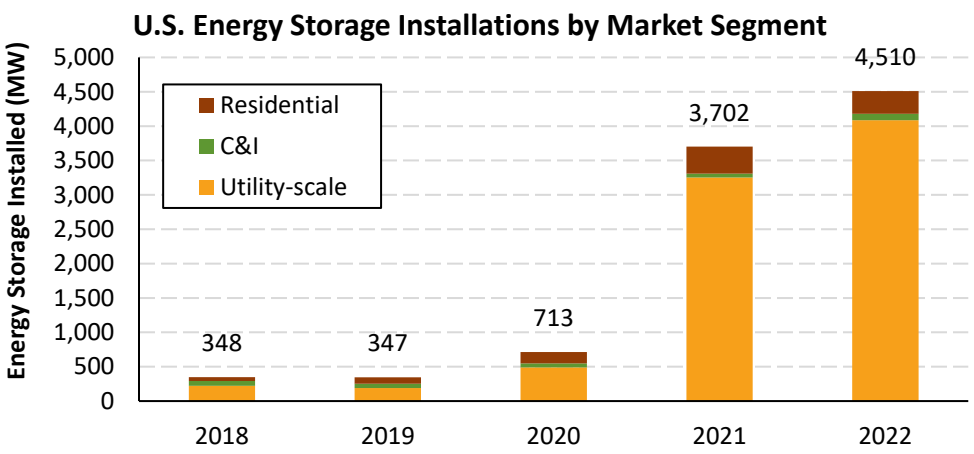
U.S. Energy Storage Installations by Market Segment (EIA)

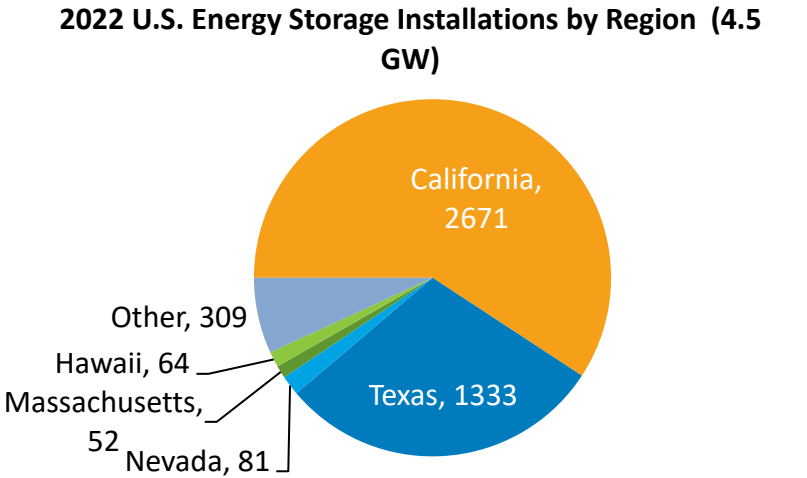
The United States installed approximately 4.5 GW_{ac} of energy storage onto the electric grid in 2022— up 22% y/y as a result of high levels of utility-scale and C&I deployment.

– EIA reported a 16% reduction in residential storage installations.

California represented 59% of installed battery storage capacity, followed by Texas (30%).

– The top five markets represented 93% of installed energy storage capacity.





Note: EIA reports no storage from Puerto Rico.

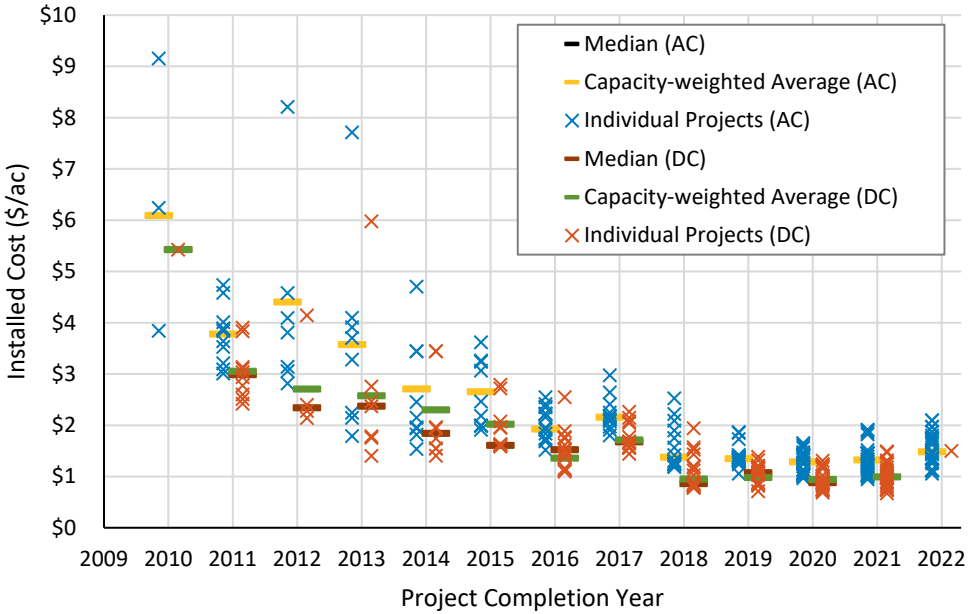
Sources: EIA Form 860M.

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 202 projects totaling 9.6 GWac installed from 2010 to 2022, the median system price in 2022 was $1.49/Wac—up 13% y/y.**
- **The median reported price by EnergySage for residential PV systems increased 6.3% y/y to $2.85/Wdc – the third straight period of increase, after never having done so before.**
- **From H1 2022 to early 2023, the median reported distributed PV system price across Arizona, California, Massachusetts, and New York:**
  - Increased 5% to $4.40/Wdc for systems 2.5 to 10 kW
  - Increased 9% to $3.92/Wdc for systems 10 to 100 kW
  - Increased 4% to $2.59/Wdc for systems 100 to 500 kW
  - Increased 13% to $2.08/Wdc for systems 500 kW to 5 MW.

Utility-Owned PV Pricing (>5 MW)

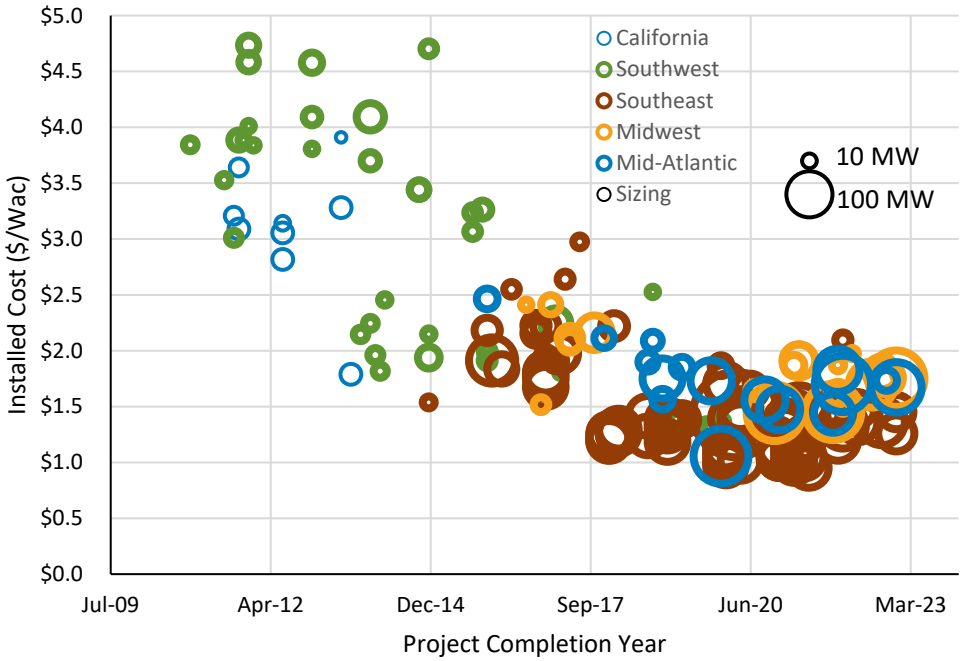


In a select data set of utility-scale PV systems owned by 25 regulated utilities for 202 projects totaling 9.6 GWac installed from 2010 to 2022, the median system price in 2022 was $1.49/Wac—up 13% y/y.

- The lowest and highest reported prices in 2022 were $1.06/Wac and $2.10/Wac, respectively.
- Still, from 2010 through 2022, system prices fell 11% per year.

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

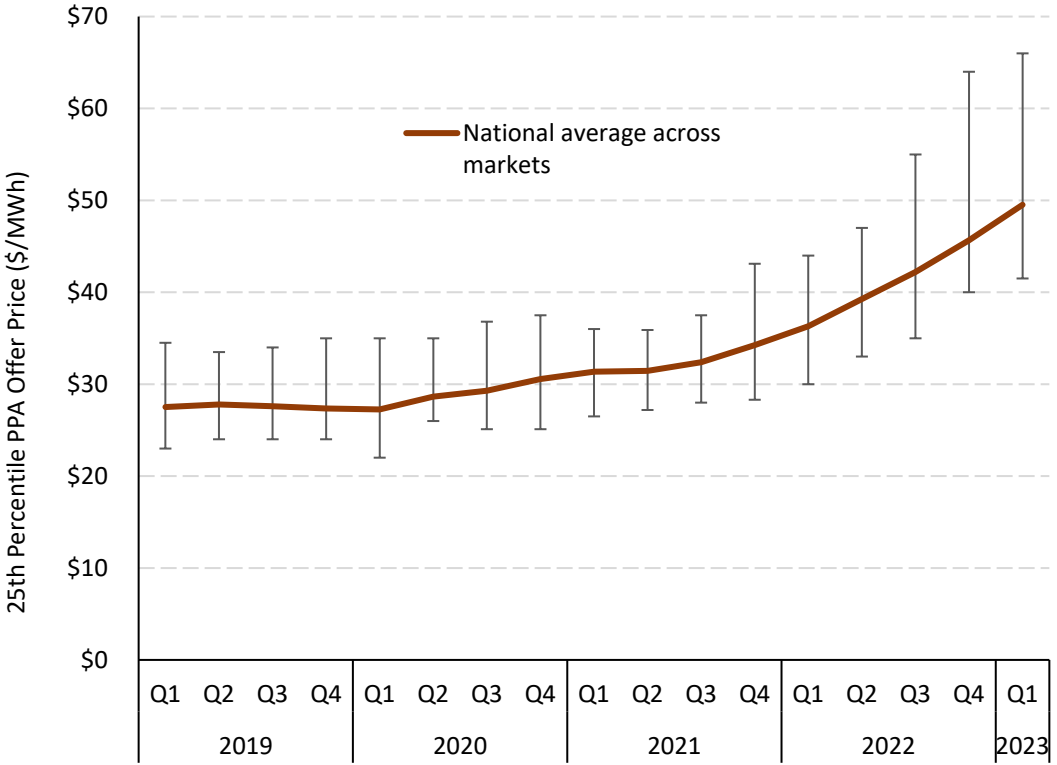
Utility-Owned PV Pricing (>5 MW)



- While geographic considerations (as well as size) impact cost per watt, system prices have been relatively in-line across several different regions but generally lower in the Southeast.
  - The data sample had a capacity-weighted average price of $1.48/Wac in 2022.
  - The capacity-weighted average price in the Southeast was $1.28/Wac compared to $1.74/Wac in the Midwest and Mid-Atlantic.
  - 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.

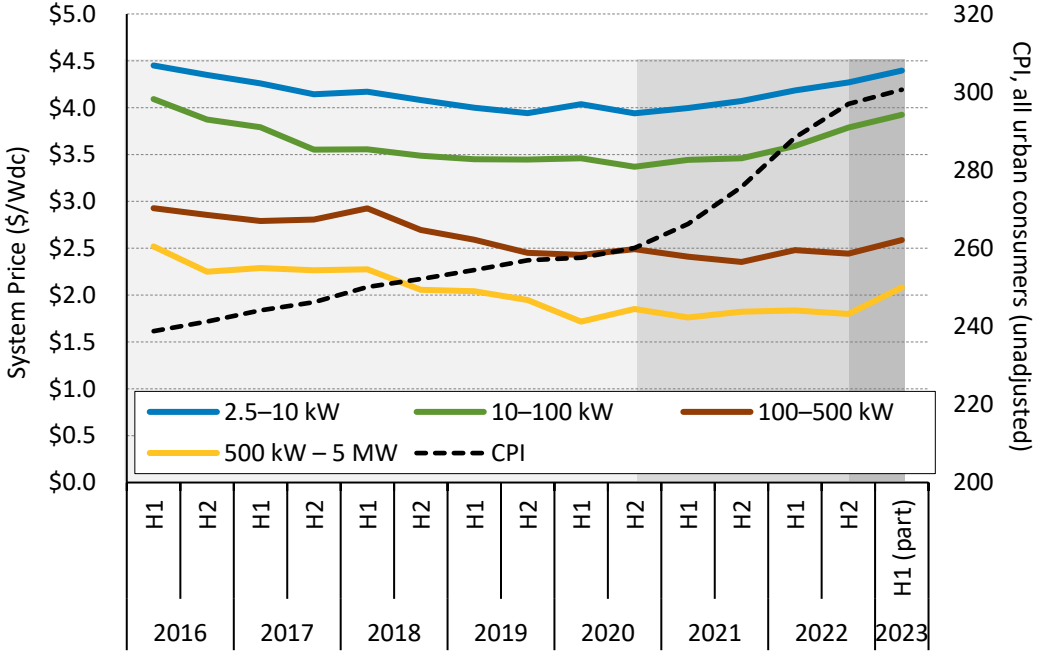
U.S. Solar PPA Pricing (LevelTen)



- U.S. Solar PPA prices increased between 2020 and 2023, with the 25th percentile offered price in Q1 2023 on LevelTen's bidding platform 82% higher than it was in Q1 2020.
  - Offered wind PPA's increased 113% over the same period.
- LevelTen attributed the increase in pricing to rising supply chain costs, capital costs (e.g., rising interest rates), regulatory uncertainty, and logistical complexity (e.g., meeting UFLPA, and managing anti-circumvention case on U.S. import of Southeast Asian cell and modules).

Source: LevelTen, PPA Price Index.

Distributed PV System Pricing From Select States



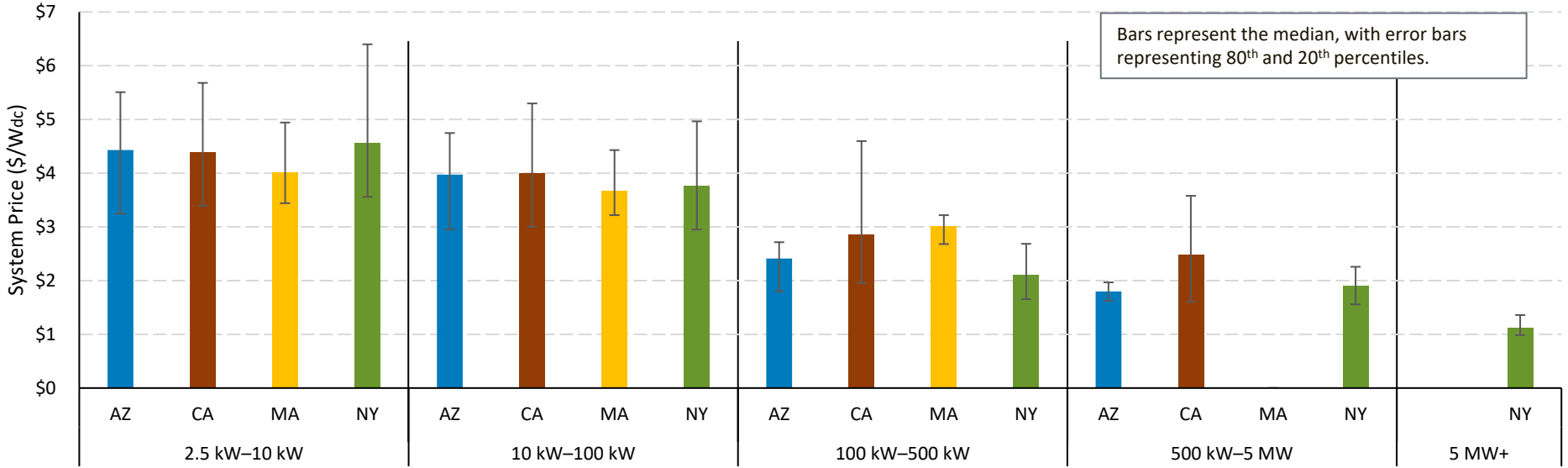
2023 MW reported YTD: Arizona (64), California (224), Massachusetts (15), New York (118)
Note: System prices above $10/W and below $0.75/W were removed from the data set. There were not enough reported prices for systems above 5 MW in the data set to show a trend over time.
Sources: Arizona Goes Solar (4/10/23); California Distributed Generation (2/28/23); Massachusetts Lists of Qualified Generation Units (4/5/23); Solar Electric Programs Reported by NYSERDA (3/3/23).

- From H1 2022 to early 2023, the median reported distributed PV system price across Arizona, California, Massachusetts, and New York:
  - Increased 5% to $4.40/Wdc for systems 2.5 to 10 kW
  - Increased 9% to $3.92/Wdc for systems 10 to 100 kW
  - Increased 4% to $2.59/Wdc for systems 100 to 500 kW
  - Increased 13% to $2.08/Wdc for systems 500 kW to 5 MW.
- From 2016 through 2020, the CPI change averaged +2% per year, while system price changes averaged -2% to -6% per year.
- From 2020 through 2022:
  - The CPI change averaged +6% per year.
  - The price change for systems 2.5–100 kW averaged +3% to +4% per year.
  - The price change for systems 100 kW – 5 MW averaged -1% to +1% per year.
- From H2 2022 through early 2023:
  - The CPI changed +2%.
  - The price for systems 2.5–100 kW changed +3% to +4%.
  - The price for systems 100 kW – 5 MW changed +6% to +16%.

Distributed System Pricing From Select States, Early 2023

- 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 H1 2022 and early 2023:
  - 2%–10% in Arizona, 5%–10% in California, 4%–5% in Massachusetts, 13% in New York.
- California drove the overall trend toward higher large-system prices from H1 2022 to early 2023, both installing the most capacity and reporting the largest price increases (13%–36%) for systems of 100 kW – 5 MW.



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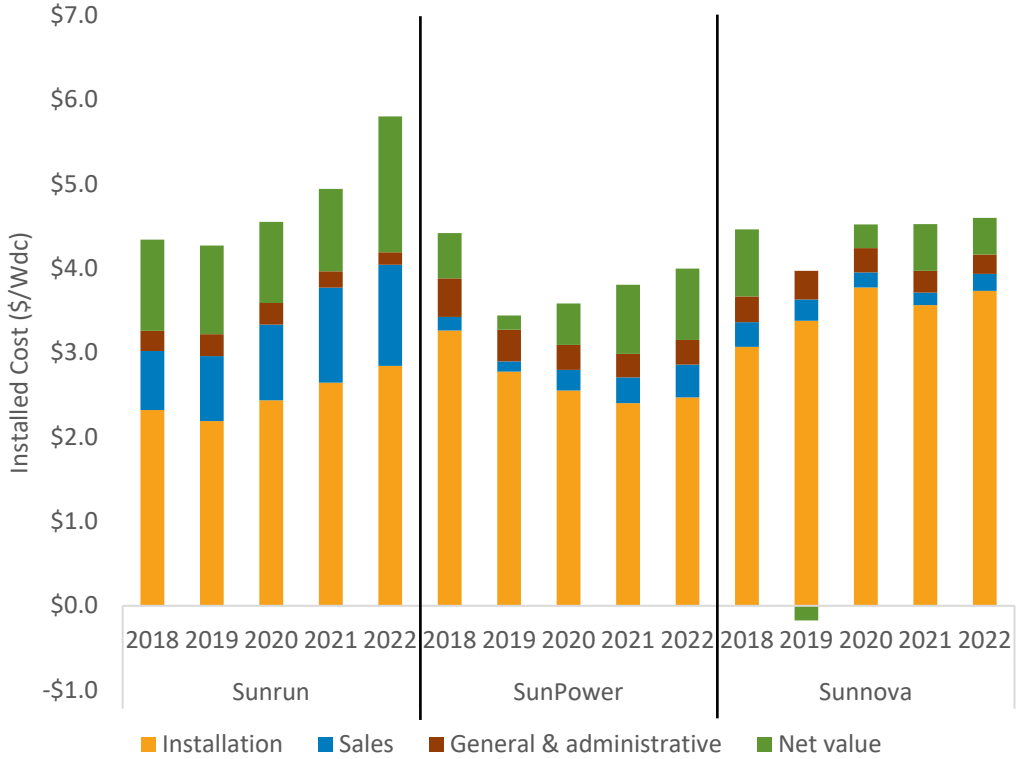
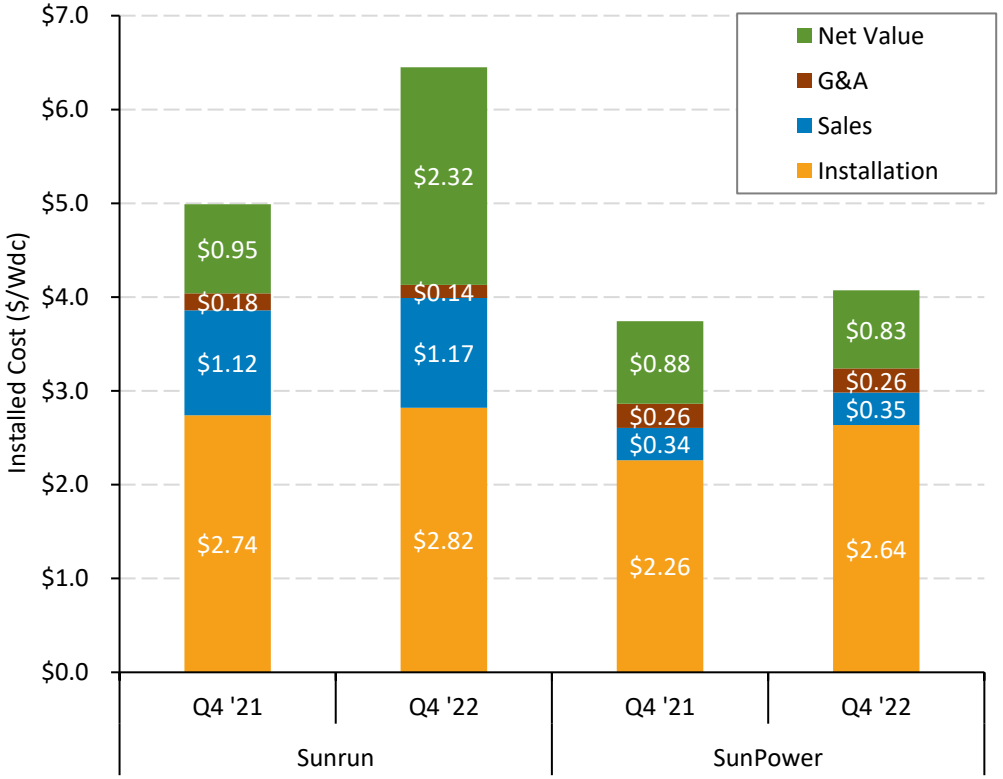
Sunrun, SunPower, and Sunnova Cost and Value, 2018–2022



- After falling in 2019, the prices of residential systems installed by national integrators rose in each subsequent year through 2022.
  - Some of this rise is due to the inclusion of storage into sold or leased PV systems.
- Net customer value showed an increasing trend for all companies between 2019 and 2022.
- Increases in sales and installation costs also contributed to price increases, with the contribution from each category varying by company.
- General and administrative costs exhibited a decreasing trend across companies.

Sources: Corporate filings.

Sunrun and SunPower Cost and Value, Q4 2022

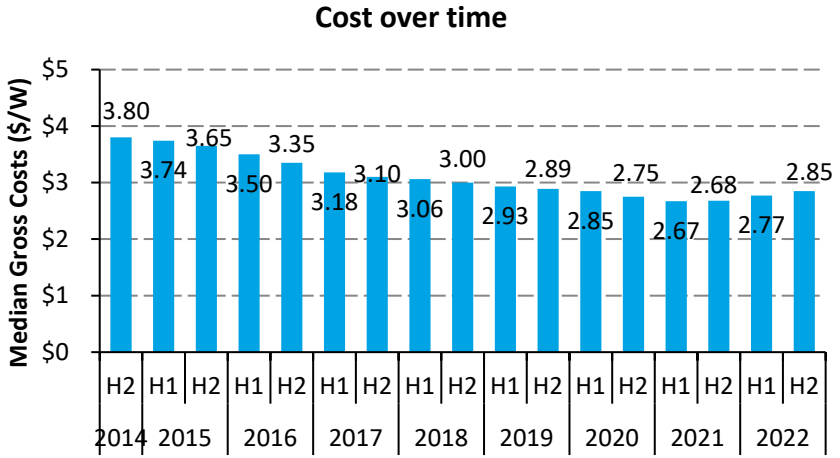


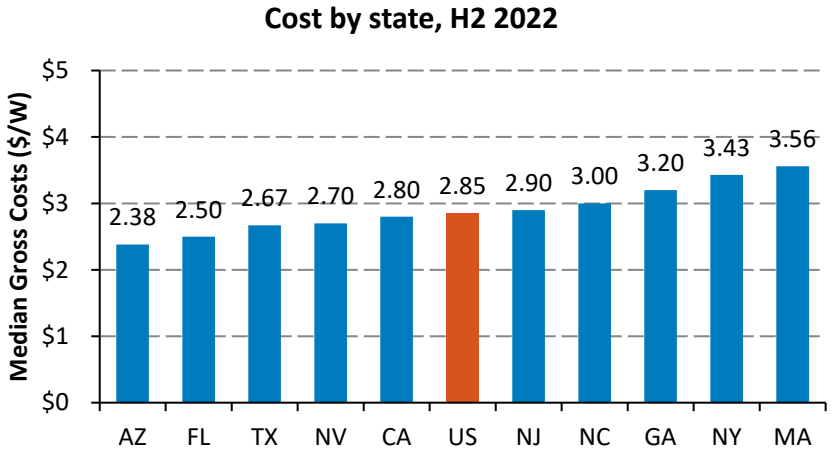
- Large residential installers reported continued strong demand for PV in Q4 2022 along with rising prices.
  - New customer additions increased 25%–81% in Q4 2022 vs. Q4 2021 for Sunrun, Sunnova, and SunPower, and large customer backlogs were reported (e.g., 53,000 customers for SunPower).
  - Installers credited the high cost of residential utility service for boosting PV demand and accommodating higher PV prices.
  - California's April 2023 net-metering change drove demand, after which PV plus storage systems are expected to gain in popularity.
  - Other demand drivers include increased electric vehicle purchases, creation of virtual power plants, PV on new home construction, and Inflation Reduction Act incentives.
- Prices include PV systems paired with batteries.
  - Battery attachment rates were 17% for SunPower and 22% for Sunnova in Q4 2022
  - Sunrun's rate was 15% for the entire year.
- Installers reported few equipment supply issues, in contrast to a focus on these issues in recent quarters.

Sources: Corporate filings.

Residential System Price Reported by EnergySage

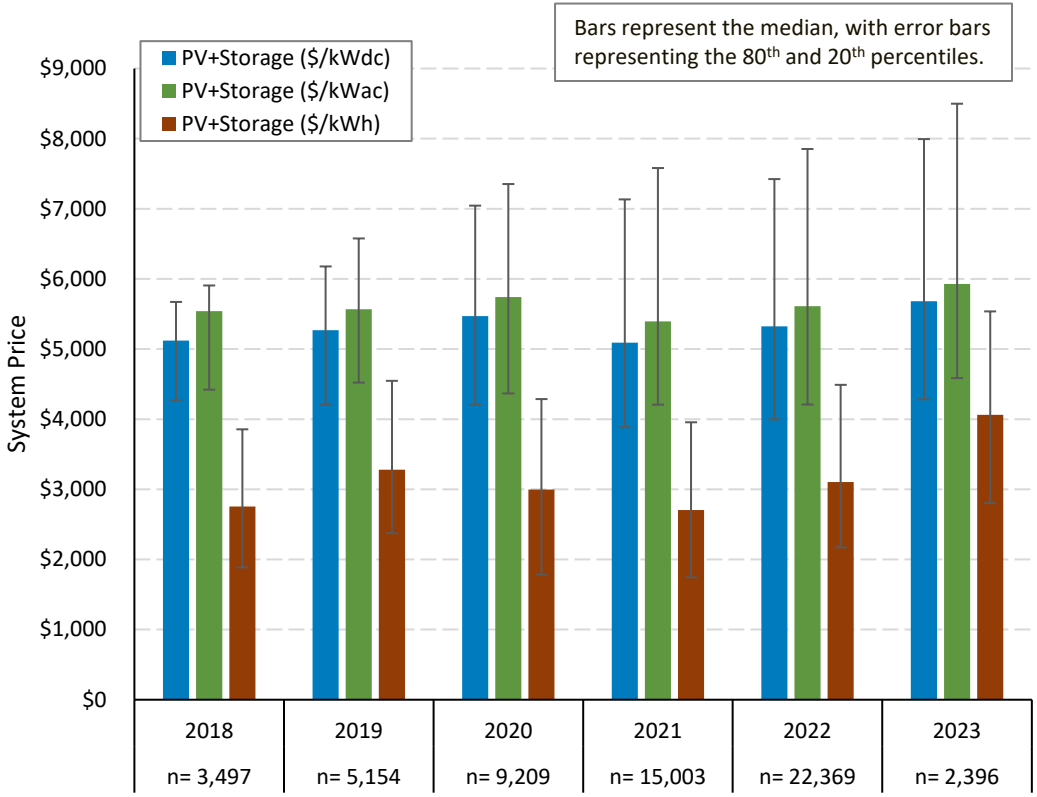
- The median reported price by EnergySage for residential PV systems increased 6.3% y/y – the third straight period of increase, after never having done so before.
  - EnergySage attributed the price increase to supply chain disruptions.
- Residential system price varied by state. In H2 2022, the median price of a residential system in Massachusetts was 50% 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 2022 – H2 2022.

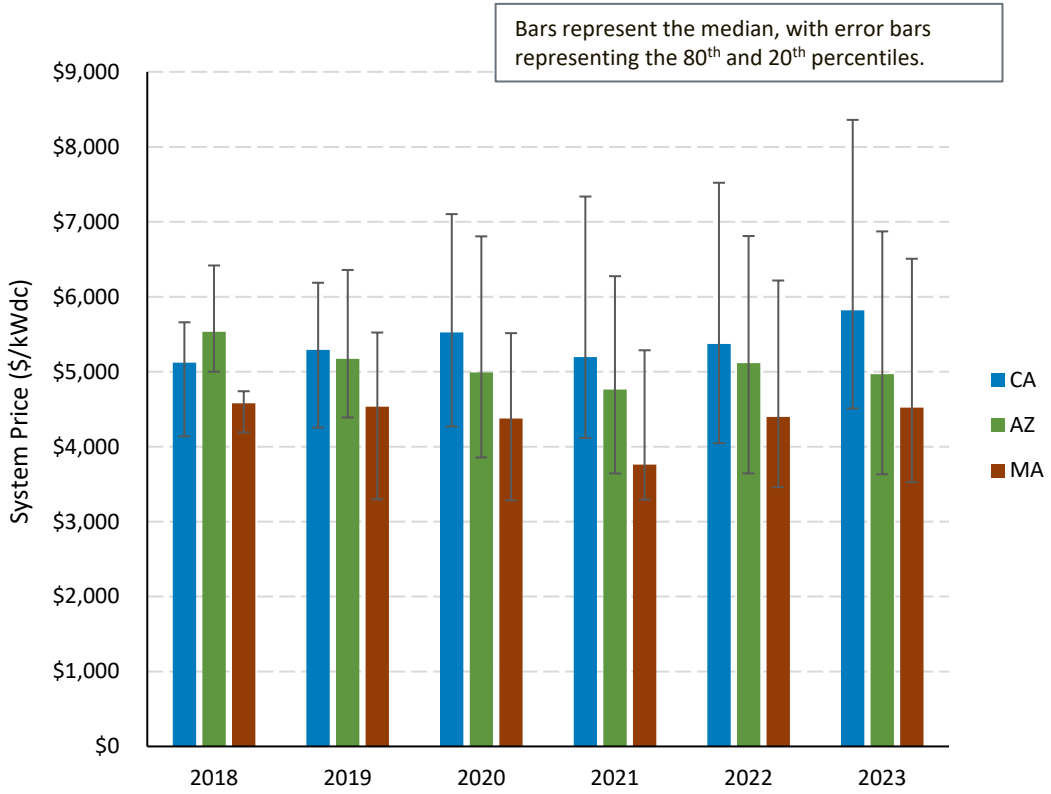
Residential U.S. PV+Storage Pricing



- In the first few months of 2023, residential PV+storage systems in Arizona, California, and Massachusetts had a median system price of $4,100/kWh, or $5,900/kWac ($5,700/kWdc)—an increase of 6%–31% compared with full 2022 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).

2023 YTD residential PV+storage sample, after data cleaning (MWdc): Arizona (6), California (17), Massachusetts (1)
Sources: Arizona Goes Solar (4/10/23); California Distributed Generation (2/28/23); Massachusetts Lists of Qualified Generation Units (4/5/23).

Residential U.S. PV+Storage Pricing

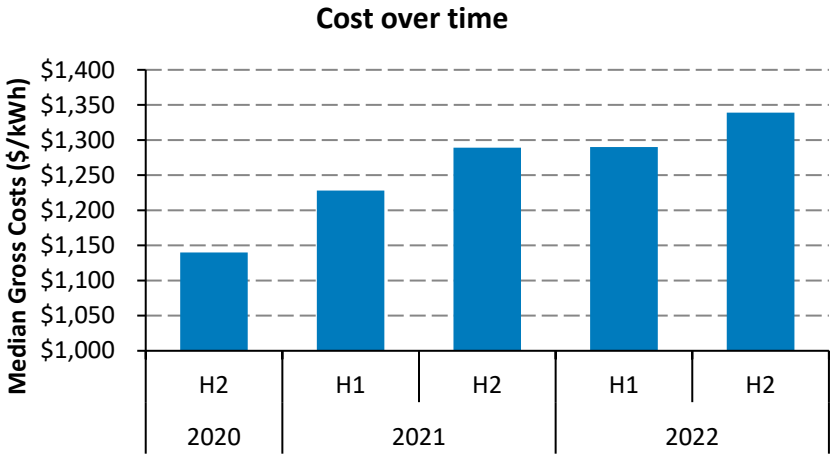


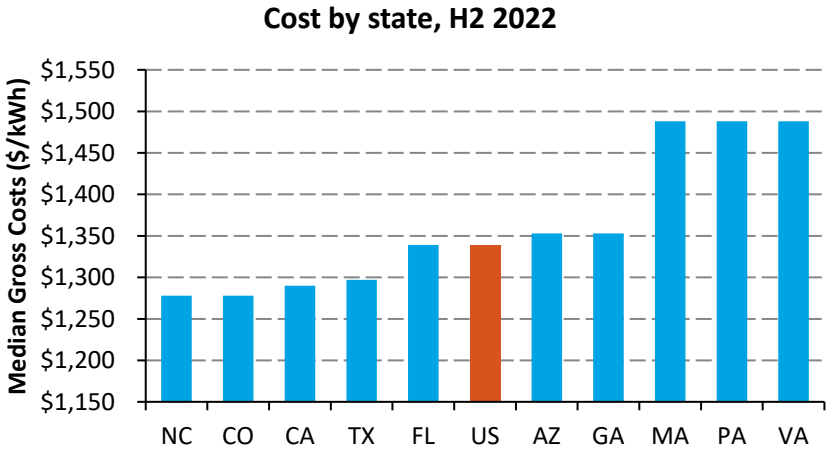
- In the first few months of 2023, residential PV+storage system prices in Arizona, California, and Massachusetts varied between states and internally.
  - Prices may vary due to differences in storage power and capacity, permitting and interconnection differences, local competitive factors, and installer experience.
- Compared with full median 2022 values, prices (in dollars per kWdc of PV capacity) increased in the first few months of 2023 in California (8%), and Massachusetts (3%) while decreasing in Arizona (3%).

2023 YTD residential PV+storage sample, after data cleaning (MWdc): Arizona (6), California (17), Massachusetts (1)
Sources: Arizona Goes Solar (4/10/23); California Distributed Generation (2/28/23); Massachusetts Lists of Qualified Generation Units (4/5/23).

Residential Storage Price Reported by EnergySage

- The median reported price by EnergySage for residential energy storage increased 3.9% y/y.
  - EnergySage has shown an increase in energy storage price since it first started reporting in 2020.
- Residential storage system price varied by state. In H2 2022, the median price of a residential storage system in Massachusetts, Pennsylvania, and Virginia were 16% higher than the median price of a residential storage system in North Carolina.
  - In the EnergySage data set, the median cost of a battery in the top ten states ranged from $13,000 to $18,000.





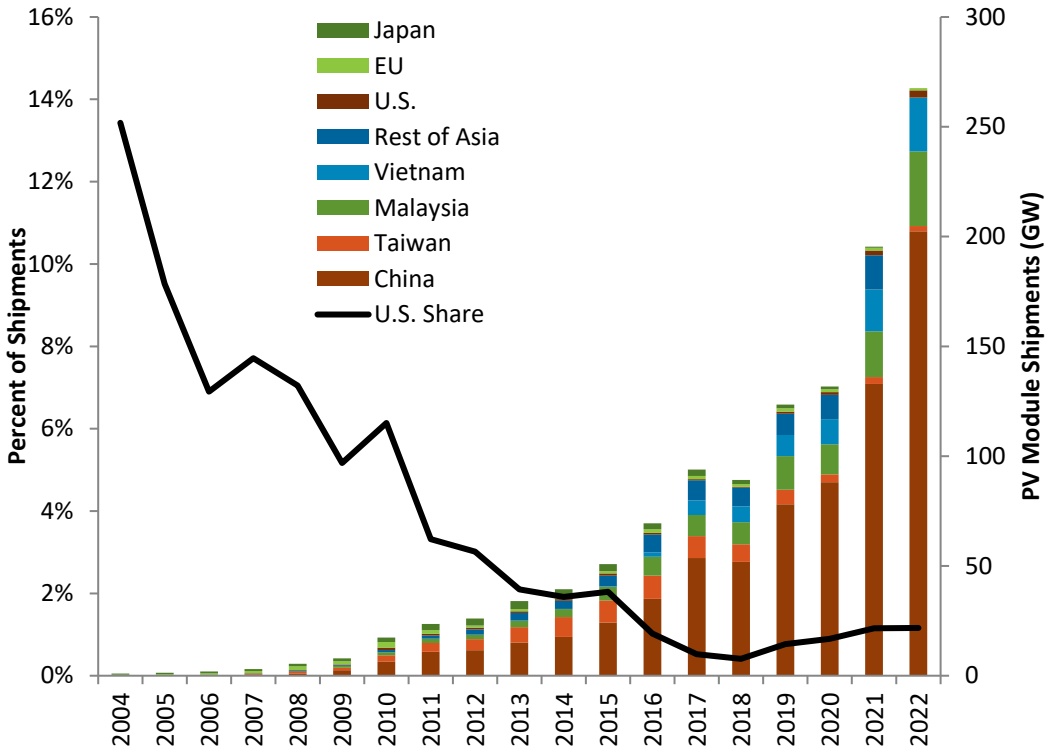
Note: Price based on winning quoted price.
Source: EnergySage, Solar Market place Intel Report H1 2022 – H2 2022.

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

- **In 2022, global PV shipments were approximately 283 GW—an increase of 46% from 2021.**
- **In 2022, 96% of PV shipments were mono c-Si technology, compared to 35% in 2015.**
  - N-type mono c-Si grew to 51% - up from 20% in 2021 (and 5% in 2019).
- **In 2022, the average module efficiency of modules installed in the United States was approximately 20.7% for mono c-Si, 17.5% for multi c-Si, and 18.5% for CdTe.**
- **In 2022, the United States produced a around 5 GW of PV modules.**
- **Since the IRA's passage, nearly 110 GW of manufacturing capacity has been announced across the solar supply chain, including 26 separate new manufacturing plants.**

Global Annual PV Shipments by Region*

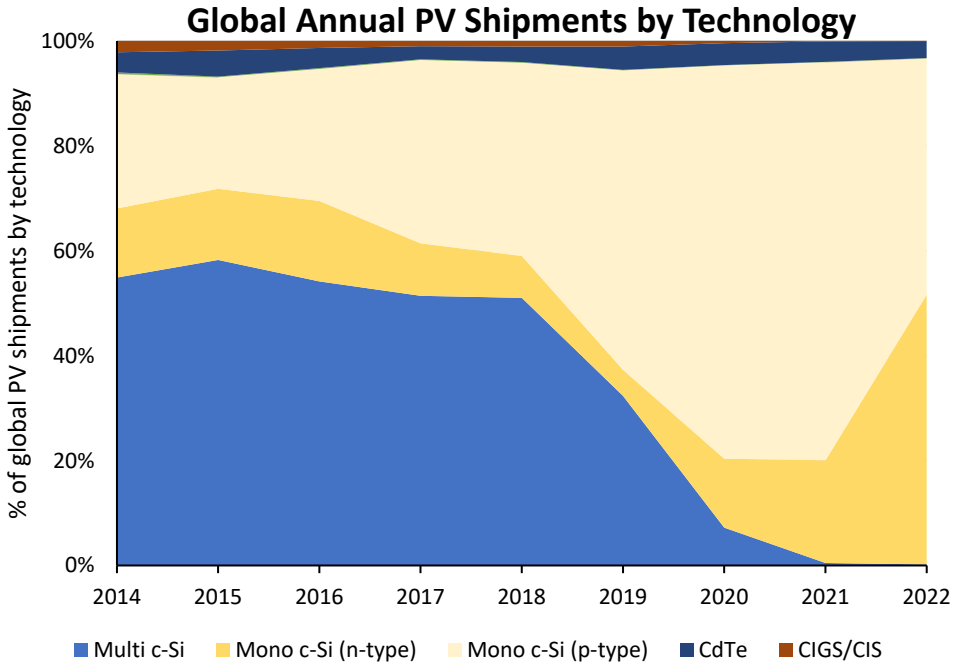


- In 2022, global PV shipments were approximately 283 GW—an increase of 46% from 2021.
  - ¾ of the increase came from China, with the remainder mostly coming from Southeast Asia.
  - U.S. production also grew 47%.
- From 2004 to 2022:
  - The U.S.-manufactured percentage of global PV shipments declined 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 71%.
  - Together the Malaysian-, Vietnamese-, and South Korean-manufactured percentage of global PV shipments went from 0% to 23%.

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

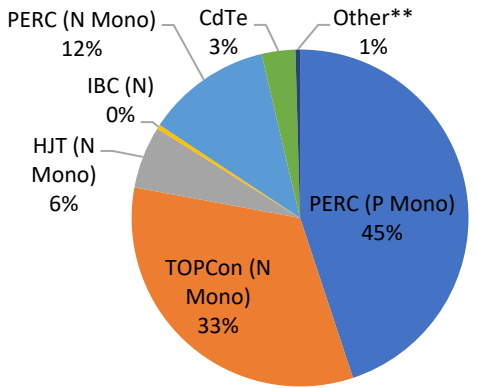
Source: Paula Mints. "Photovoltaic Manufacturer Capacity, Shipments, Price & Revenues 2022/2023." SPV Market Research. Report SPV-Supply11. April 2023.

Global Annual PV Shipments by Technology*



- In 2022, 96% of PV shipments were mono c-Si technology, compared to 35% in 2015.
  - N-type mono c-Si grew to 51% - up from 20% in 2021 (and 5% in 2019).
- Mono P PERC was the leading cell type in 2022, followed by TOPCon, Mono N PERC, and HJT.

2022 Global PV Shipments by Technology



***Notes:** excludes inventory sales and outsourcing
** includes a-Si, CIS/CIGS, TOPCon (P Mono), and Multi PERC.
Source: Paula Mints. "Photovoltaic Manufacturer Capacity, Shipments, Price & Revenues 2022/2023." SPV Market Research. Report SPV-Supply11. April 2023.

Global Leading PV Manufacturers by Shipments

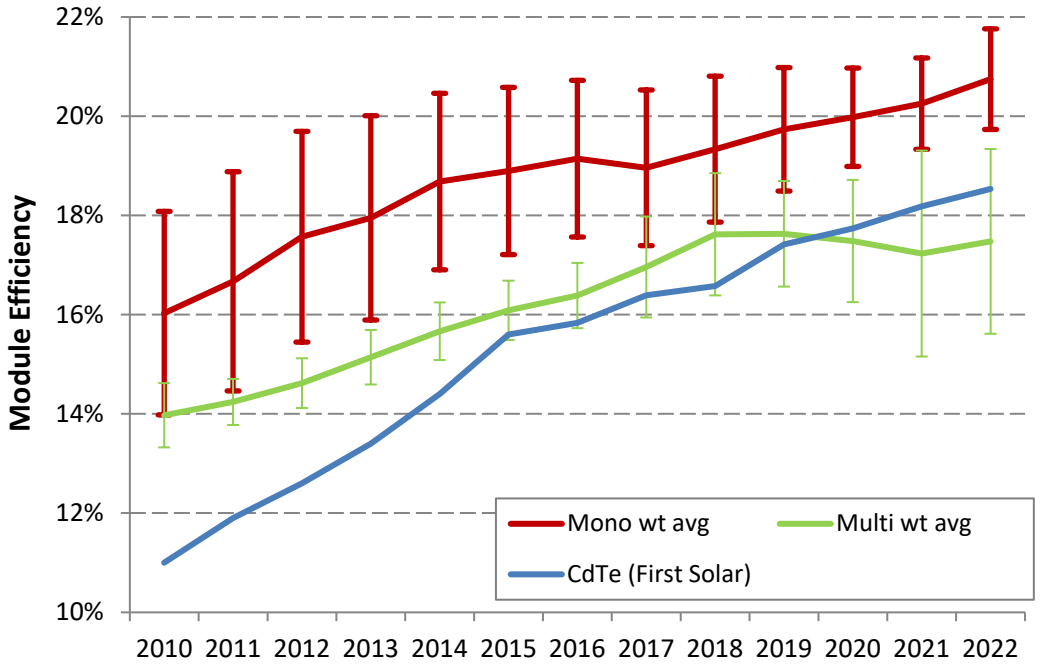
Ranking	2017	GWp	2021	GWp	2022	GWp
1	JA Solar	6.5	Aiko	31.3	Tongwei	38.1
2	Canadian Solar	5.4	Tongwei	27.3	JA Solar	36.2
3	Zhongli Talesun	5.0	LONGi	19.6	Aiko	30.7
4	Jinko Solar	4.9	Jinko Solar	16.8	LONGi	29.2
5	Trina Solar	4.8	Zhongli Talesun	10.7	Jinko Solar	23.9
6	LONGi	4.5	JA Solar	10.7	Canadian Solar	16.8
7	Hanwha Q Cells	4.2	Canadian Solar	8.7	Trina Solar	14.5
8	Tongwei	3.8	Runergy	8.0	SolarSpace	11.6
9	Motech	3.2	Hanwha Q-Cells	7.6	Zhongli Talesun	9.8
10	Aiko	3.1	First Solar	7.6	First Solar	9.1
Total Above		**45.5**		**148.4**		**220.0**
Total Shipped		**93.9**		**194.0**		**283.1**

- From 2017 to 2022, shipments from the top 10 PV manufacturers grew from 46 GW to 200 GW, with some companies shipping more than 30 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 2021 and 2022, and eight of the ten leading manufacturers from 2017 remain.
  - Only four companies remained in the top ten between 2012 and 2017.

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

Source: Paula Mints. "Photovoltaic Manufacturer Capacity, Shipments, Price & Revenues 2022/2023." SPV Market Research. Report SPV-Supply11. April 2023.

PV Efficiency Improvements



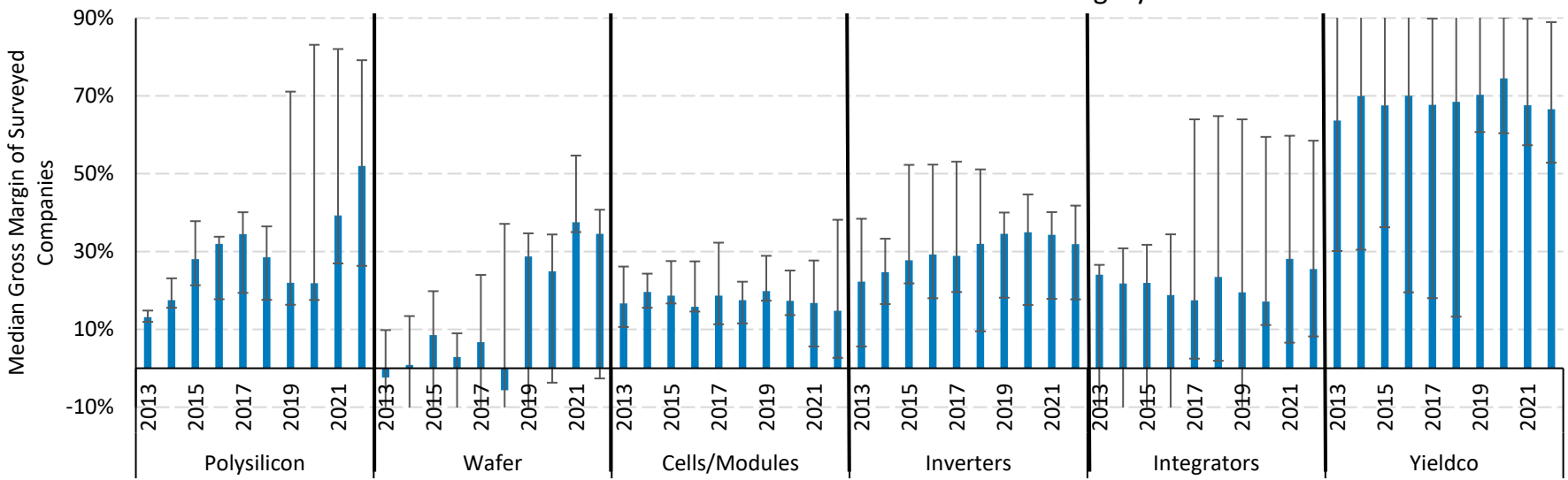
- From 2010 to 2022, the weighted average efficiency of installed modules increased:
  - 16.0% to 20.7% for mono c-Si (Calif.)
  - 14.0% to 17.5% for multi c-Si (Calif.)
  - 11.0% to 18.5% for CdTe (U.S.)
- The variability in efficiency across modules decreased during this period for mono c-Si but increased for multi c-Si, while mono-Si almost completely replaced multi-Si in the market.
- The variability of mono c-Si has decreased in part because mainstream mono c-Si modules have closed the efficiency gap with the highest-efficiency technologies.
  - For example, the gap between non-SunPower mono c-Si modules and SunPower mono c-Si modules was 3.8 percentage points in 2010, decreasing to 1.2 points in 2022.

Sources: CdTe: First Solar Investor Relations, average module efficiency produced. c-Si: California Interconnection Dataset (2/28/23). Error bars represent +/- 1 weighted standard deviation.

Gross Margin Across Supply Chain

- Polysilicon suppliers achieved historic margins in 2022, aided by an undersupply within the marketplace.

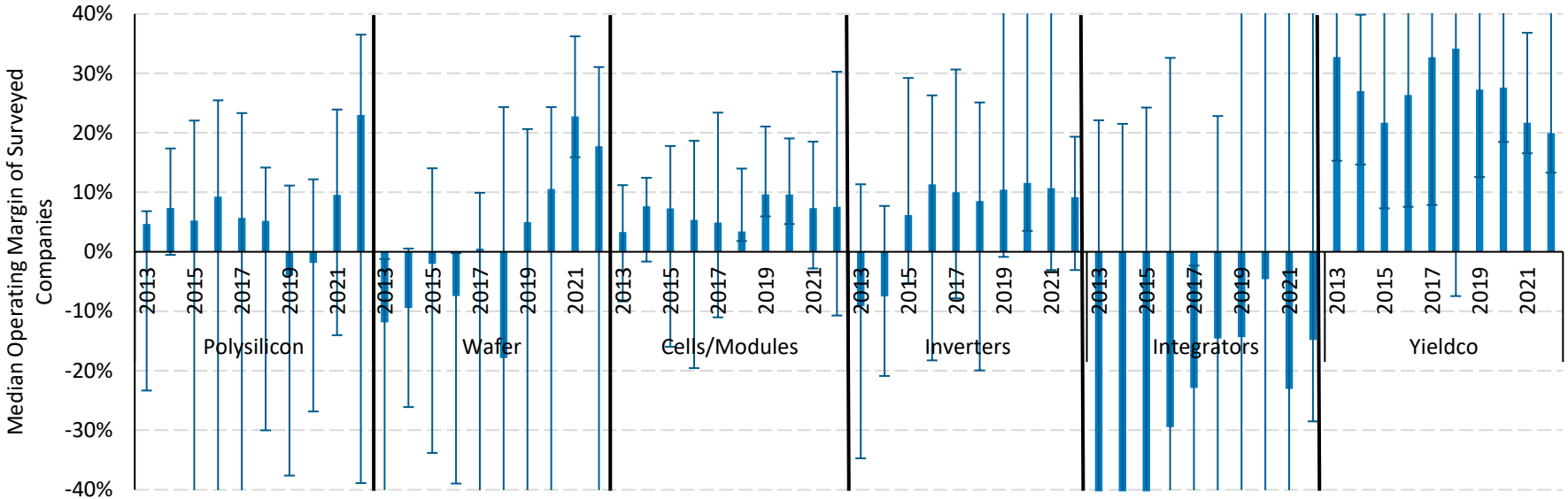
- Higher material cost (e.g., polysilicon) and continued supply chain disruptions contributed to lower gross margins, y/y of other market segments, however most industries are still achieving relatively high margins from a historical perspective.
  - Many large manufacturers are leading across c-Si process steps and therefore do not fit just within one category.



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, Xinte, Daqo; Wafers - ReneSola, Wafer Works Corp, SAS, Danen Technology Group, Green Energy Technology Inc; Cells/Modules, First Solar, JA Solar, LONGi, Tongwei, Trina Solar, Canadian Solar, Risen, Aiko, Jinko Solar, DMEGC; Inverters – SolarEdge; Enphase; SMA Solar; Advanced Energy Industries; Integrators - Real Goods Solar, SolarCity, Vivint Solar, Sunrun, SunPower, Sunworks, Emeren, Isun, SPI, Enlight Renewable Energy, Sunnova; IPP/Yieldco - Brookfield Renewable Partners; Algonquin Power & Utilities Corp; Clearwater Energy, Nextera Energy Partners, Northland Power, Pattern Energy, Terraform Power, TransAlta Renewables. Data for Q4 2022 was not available for Enlight Renewable Energy, LONGi, and SMA Solar; TTM was used in place of yearly values.

Operating Margin Across Supply Chain

- With the exception of PV project integrators, solar companies generally remained profitable, aided by robust gross margins (particularly for polysilicon).
- While project integrators report operating losses, many companies also finance PV projects, trading short-term losses for long-term cash flow (and profitability).



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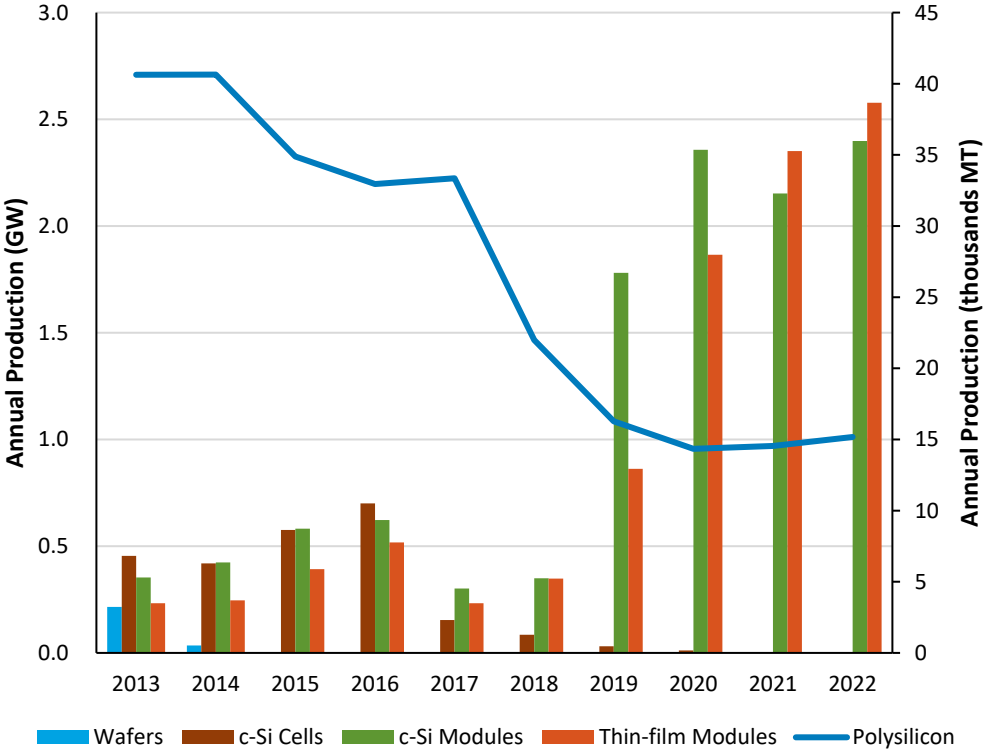
U.S. PV Manufacturing

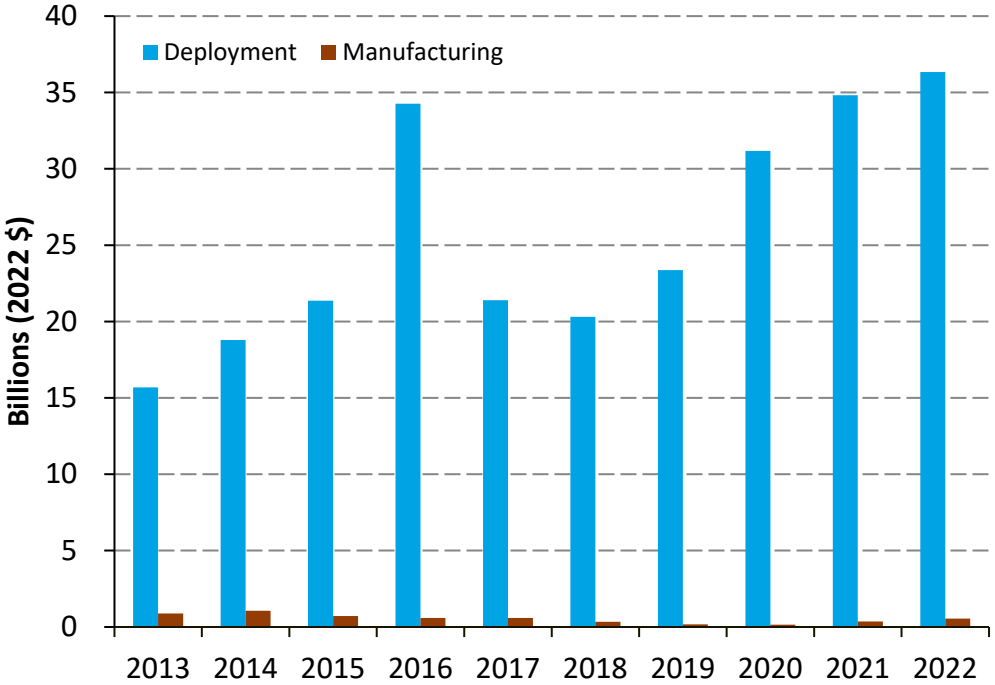


From 2013 to 2022, U.S. manufacturers faced varying degrees of challenges.

- Wafer production in the United States ended in 2014, cell production ended in 2020, and solar-grade polysilicon production dropped by 2/3.
- PV-assembled modules stagnated until 2018 but has grown by 7X since then.
  - In 2022, the United States produced approximately 5 GW of PV panels – a 10% increase over 2021.

Source: PVTech Research. PV Manufacturing & Technology Quarterly Report - Release 28 - February 2023.

Revenue of U.S. PV

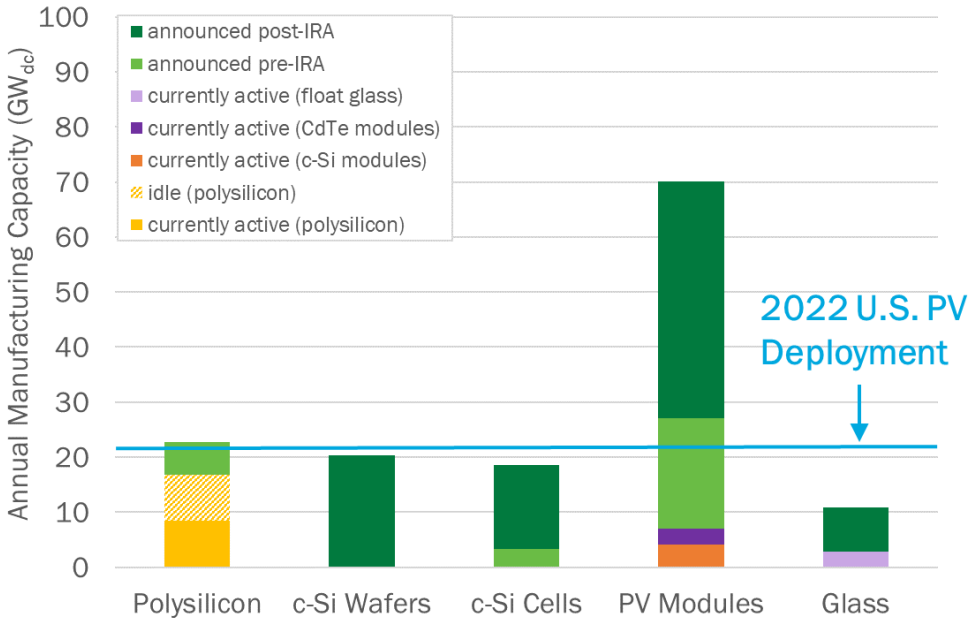


- In 2022, the U.S. PV market had more than $37B in sales of projects and manufactured products.
- While revenues from U.S. PV manufacturing (polysilicon, wafer, cell, module) increased by more than 2X between 2019 and 2022, they still only represented 1.5% of total revenues from U.S. PV system sales.
  - U.S. produced module and components had greater revenues in 2013 than in 2022 due to greater production of polysilicon, wafers, and cells, as well as higher sales prices.
- Similarly, while the U.S. installations decreased in 2022, y/y, revenues increased to record levels due to increases in PV system prices.

Note: all numbers are estimates. Manufacturing only includes polysilicon, wafer, cell, and module production. There are other parts of the U.S. supply chain, including tracking, inverters, and balance of module materials (e.g., glass).
Sources: Manufacturing levels: PVTech Research. PV Manufacturing & Technology Quarterly Report - Release 28 - February 2023. Manufacturing price: BloombergNEF. Deployment: Wood Mackenzie Power & Renewables & SEIA, "U.S. Solar Market Insight" (2014–2022). System costs: NREL Cost Benchmark. BLS.

Domestic Manufacturing Announcements

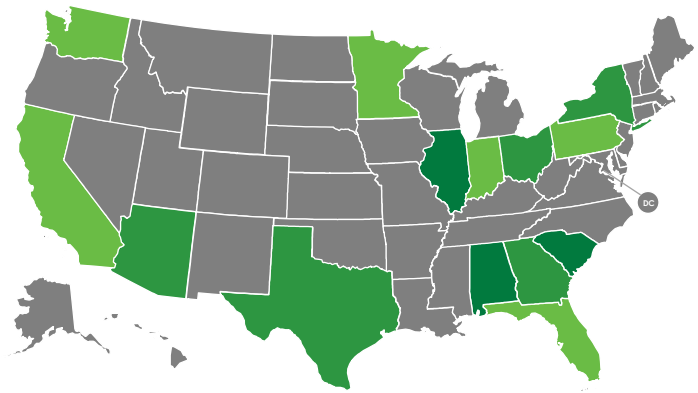
Since the IRA's passage, nearly 110 GW* of manufacturing capacity has been announced across the solar supply chain, including 26 separate new manufacturing plants.



A wide variety of announcements have been made in Q1 2023, covering wafers, cells, modules, trackers, production tools, and even PV recycling, although currently only modules have enough announced capacity to meet 2022 deployment domestically.

- Notable announcements of the last several months include:
  - 1-GW vertical cell/module facility from Silfab
  - 1-GW module facility from Hounen in SC
  - 5-GW module facility from Illuminate USA (LONGi) in OH.

These announcements pre- and post-IRA represent potential investment in at least 14 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, 8 GW of encapsulant, 1 GW of manufacturing tools, and 8 GW of inverter manufacturing not graphed.

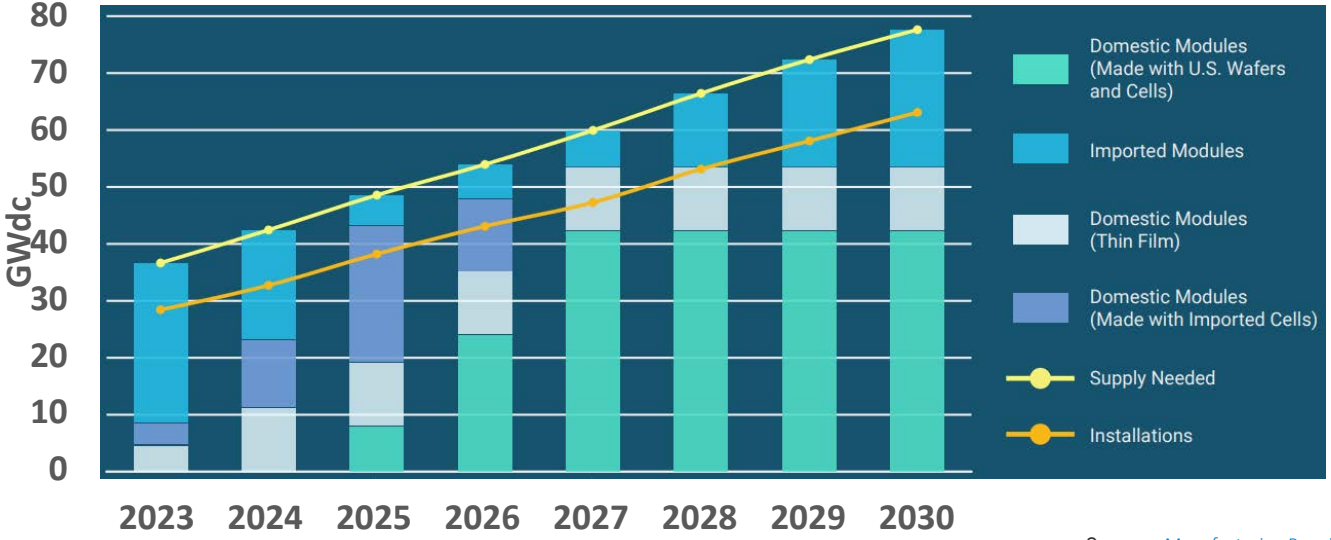
SEIA White Paper on American Manufacturing

The solar trade association SEIA released a white paper forecasting that U.S. domestic module production will exceed 50 GW by 2027, initially supplied by imported cells while domestic cell capacity is built and begins to come online in 2025.

- From 2030-2027, they predict the continued growth in installations will be supplied by imported modules.

SEIA is tracking 47 GWdc of announced module capacity, 16 GWdc of announced cells, 16 GWdc of announced wafers, nearly 9 GWac of inverters, and over 100 GWh of battery manufacturing announcements since IRA.

- They highlighted recent announcements, including: Illuminate USA (LONGi/Invenergy partnership) in Ohio making 5 GW modules, Hounen (Cambodian/Chinese) in South Carolina making 1 GW modules, Silfab (location TBD) manufacturing 1 GW cells and modules.



SEIA cautions that a self-sustaining industrial base will also require support for reshoring the manufacturing equipment and raw materials as well.

SEIA predicts that by 2030, IRA will have led to the creation of 115,000 jobs in solar and storage manufacturing, with more than half a million jobs across the entire industry.

Sources: Manufacturing Renaissance Report 2023 (seia.org), SEIA dashboard, internal DOE tracking

Agenda

1. Global Solar Deployment
2. U.S. PV Deployment
3. PV System Pricing
4. Global Manufacturing
5. **Component Pricing**
6. Market Activity
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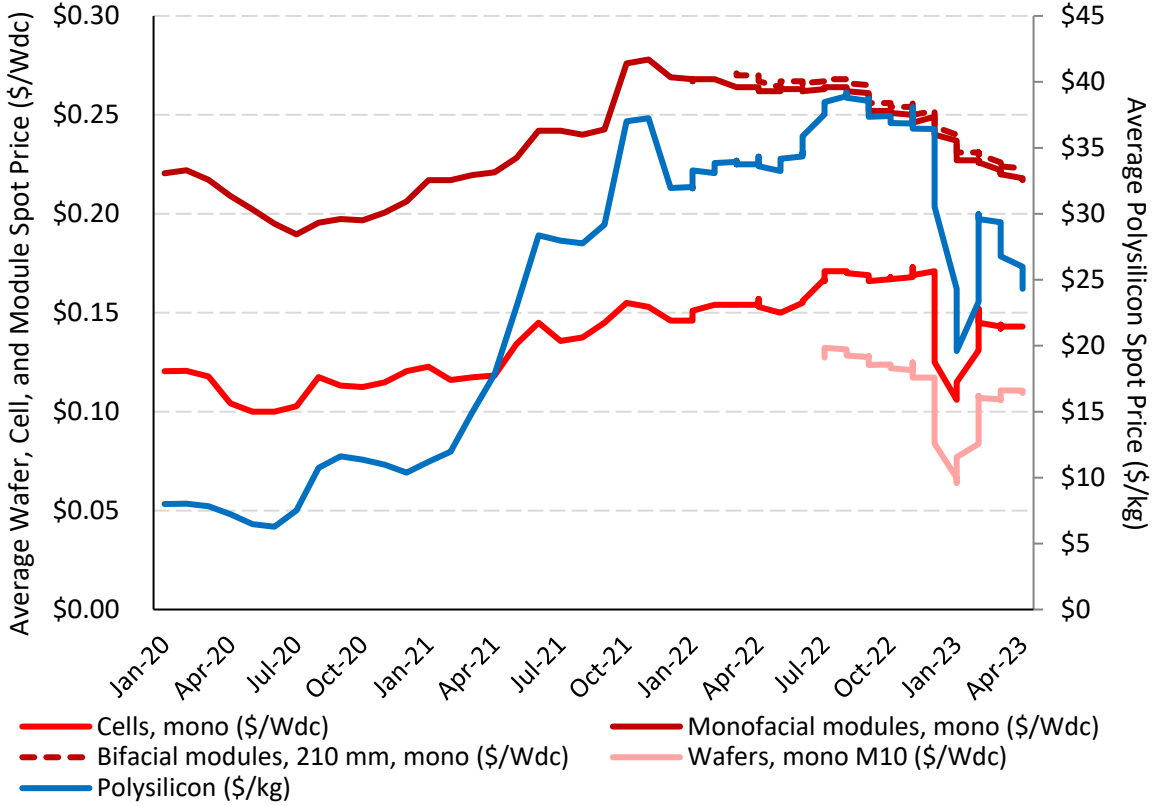
- **After plunging to a 1.5-year low of $20/kg in mid-January, global polysilicon spot prices rebounded to $30/kg in mid-February and then dropped to $24/kg by mid-April.**
- **Global module prices have declined steadily since fall 2022 despite strong demand, reaching lows in April 2023 that have not been seen for 2 years.**
- **In Q1 2023 (first 2 months), the average U.S. module price ($0.36/Wdc) was down 11% q/q and down 2% y/y, with modules trading at a 57% premium over the global spot price for monofacial monocrystalline silicon modules.**

PV Value Chain Global Spot Pricing



Source: BloombergNEF, Solar Spot Price Index (4/21/23); BloombergNEF, Bimonthly PV Index (4/17/23).

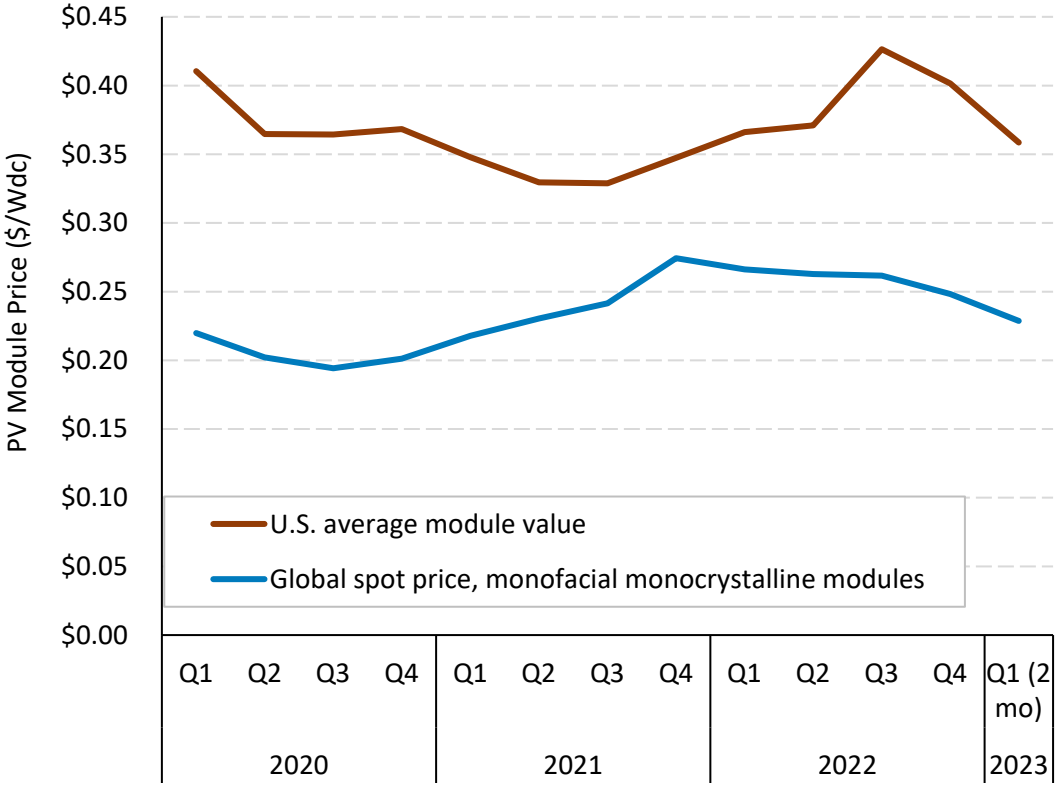
After plunging to a 1.5-year low of $20/kg in mid-January, global polysilicon spot prices rebounded to $30/kg in mid-February and then dropped to $24/kg by mid-April.

- Analysts were expecting these price reductions as more polysilicon capacity has come online and the trend toward oversupply conditions continues.
- Estimated polysilicon production in March 2023 alone would be enough to produce 40 GWdc of modules, or 1.5 times projected global module demand on an annualized basis.

After following a similar pattern early in 2023, global wafer and cell prices remained more stable in February through April.

Global module prices have declined steadily since fall 2022 despite strong demand, reaching lows in April 2023 that have not been seen for 2 years.

Module Prices: Global Versus United States



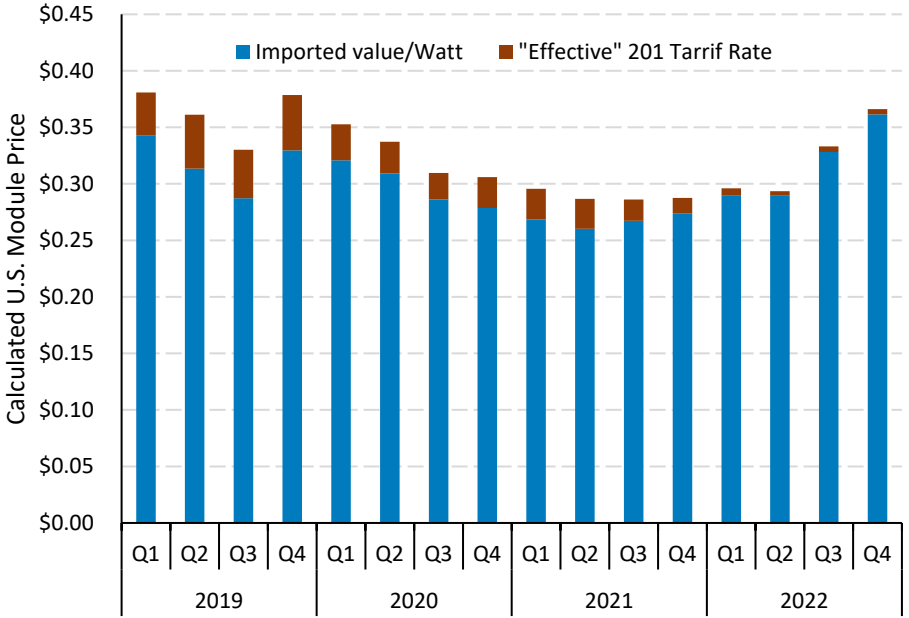
- In Q1 2023 (first 2 months), the average U.S. module price ($0.36/Wdc) was down 11% q/q and down 2% y/y, with modules trading at a 57% premium over the global spot price for monofacial monocrystalline silicon modules.
- The directional trend in U.S. module prices realigned with the trend in global module prices in Q4 2022 and Q1 2023.
  - The spike in U.S. prices in Q3 2022 was influenced by implementation of the Uyghur Forced Labor Prevention Act (UFLPA), beginning June 21, 2022.
  - Subsequently, U.S. prices declined at a more rapid pace than global spot prices.
- Clean Energy Associates projects that Chinese and Southeast Asian module prices will decline by around 15% over the next 3 years, but market prices in the U.S. will be the world's highest because of supply shortages related to the UFLPA.

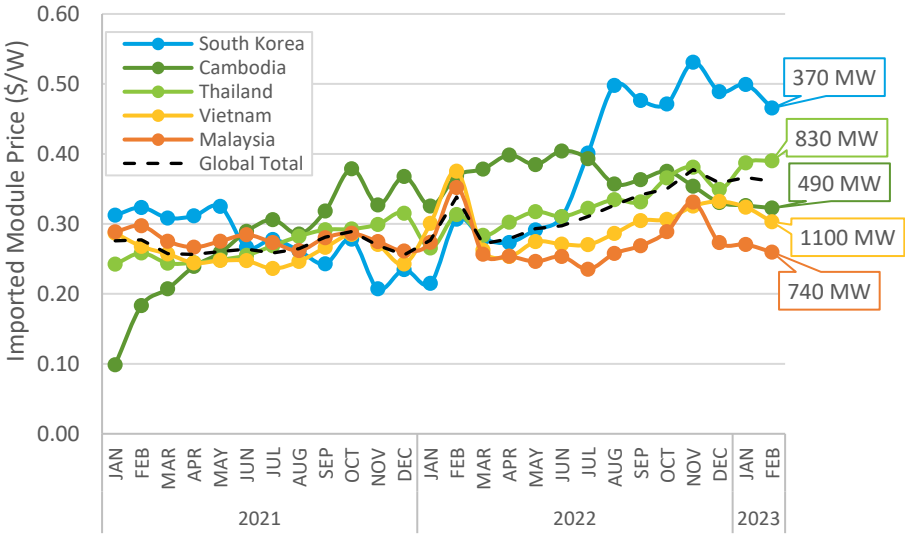
Source: BloombergNEF, Solar Spot Price Index (4/21/23); BloombergNEF, Bimonthly PV Index (4/17/23); EIA, Monthly Solar Photovoltaic Module Shipments Report (4/25/23); PV Tech (4/5/23); Wood Mackenzie & SEIA, US Solar Market Insight: 2022 Year in Review (3/23).

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 Q4 2022 to $0.36/W before tariffs.

– After climbing steadily during 2022, prices appear to be leveling off, although prices in South Korea remain elevated.

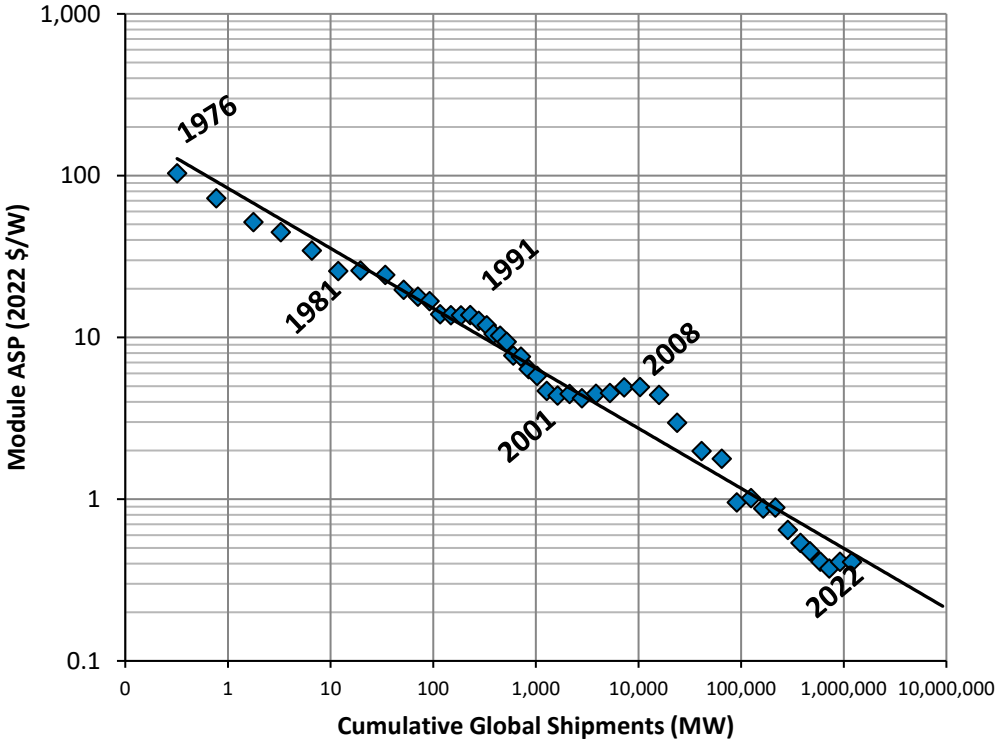




Note: The tariff rate was adjusted by the capacity subject to the tariffs. Manual corrections were made to three values due to suspected data entry errors for HTS code 8541430010: Cambodia (February 2022), Malaysia (June 2020), and Vietnam (July 2019).

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 of 4/11/23.

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 2022, there has been on average a ~22% reduction in PV module price.
- From 2008-2020, the PV industry experienced accelerated improvements, putting module ASPs below the historical experience curve since 2012 – since then, it has largely returned to the historical average.

Source: SPV Market Research. Report SPV-Supply10. April 2023.

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- **Solar stocks represented by the Invesco Solar ETF rose 6.4% in Q1 2023, largely mirroring the S&P 500, which rose 6.7%. Factors boosting solar stocks included large investments in U.S. solar manufacturing and strong demand for solar in Europe and the United States. Headwinds included concerns about inflation and interest rate increases as well as continuing uncertainty about constraints on module imports. In general, shares in manufacturers fared better than shares in installers and project developers.**

Stock Market Activity

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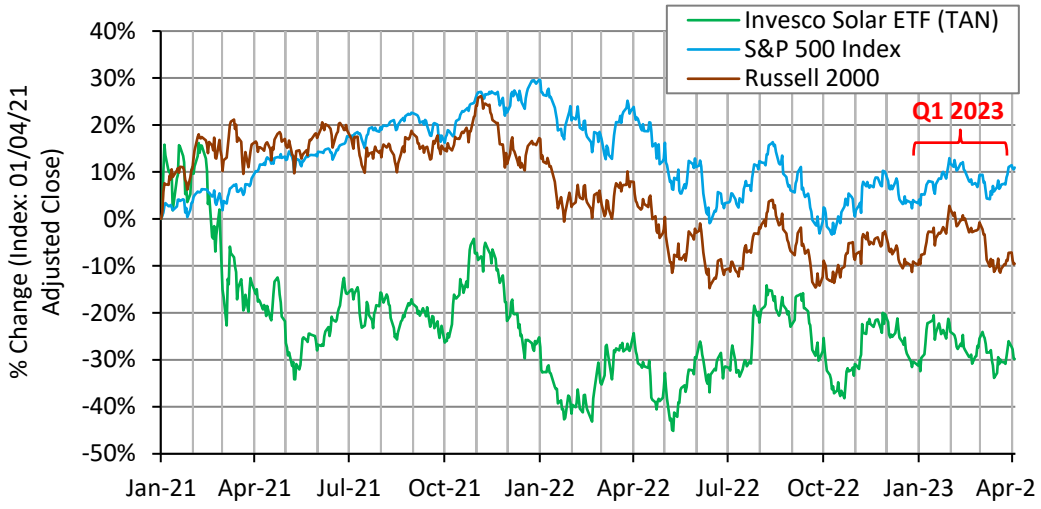
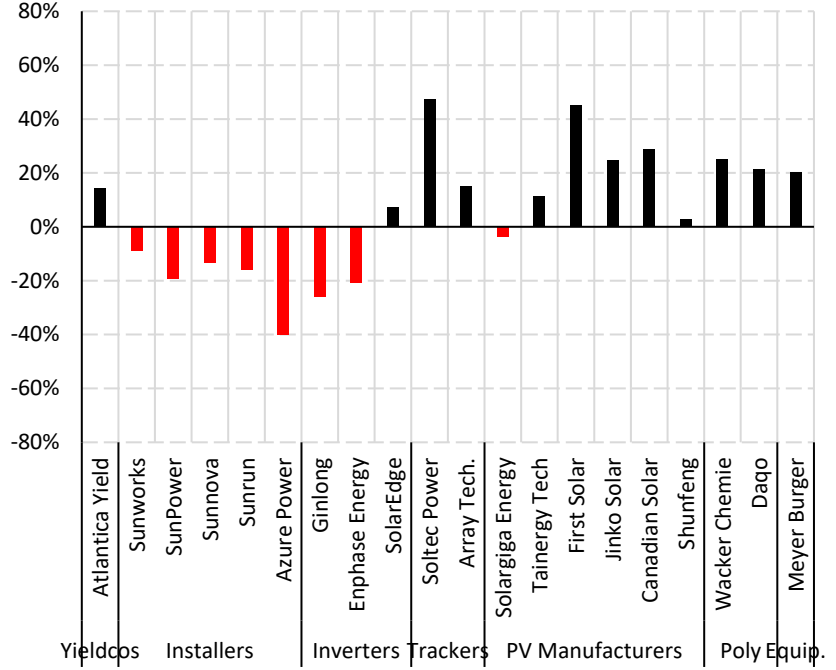


Individual Stock Performance (Q1 2023)



Note: The TAN index is weighted toward particular countries and sectors. As of 4/6/23, 46% of its funds were in U.S. companies and 21% were in Chinese companies. Its top 10 holdings, representing 55% of its value, were First Solar, Enphase, SolarEdge, Xinyi, GCL, Sunrun, Shoals, Array Technologies, Meyer Burger, and Daqo.

Sources: Invesco (4/6/23); Mercom, Solar Market Intelligence Report (4/3/23); PV Magazine (2/23, 3/23, 4/23).

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- **According to U.S. Census data, 28.7 GWdc of modules and 2.5 GWdc of cells were imported in 2022, an increase of 21% y/y (+5 GW) and 7% y/y (178 MW), respectively.**
  - **Collectively, Malaysia, Vietnam, Thailand, and Cambodia represented 73% of c-Si module imports (75% including c-Si cells).**
  - **Imports from India and South Korea grew significantly in 2022.**
- **According to U.S. Census data, 2.5 GWdc of cells were imported in 2022. Quarterly cell imports grew for the second quarter in a row in Q4 2022 (+60 MWdc, +9% q/q).**
- **In 2022, only 10% (2.7 GWdc) of modules reported a tariff, compared to 56% (13.2 GWdc) in 2021.**

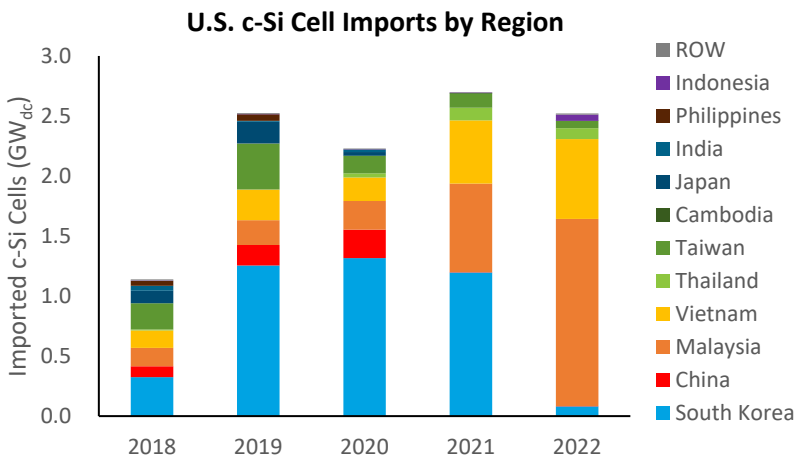
Annual c-Si Cell + Module Imports

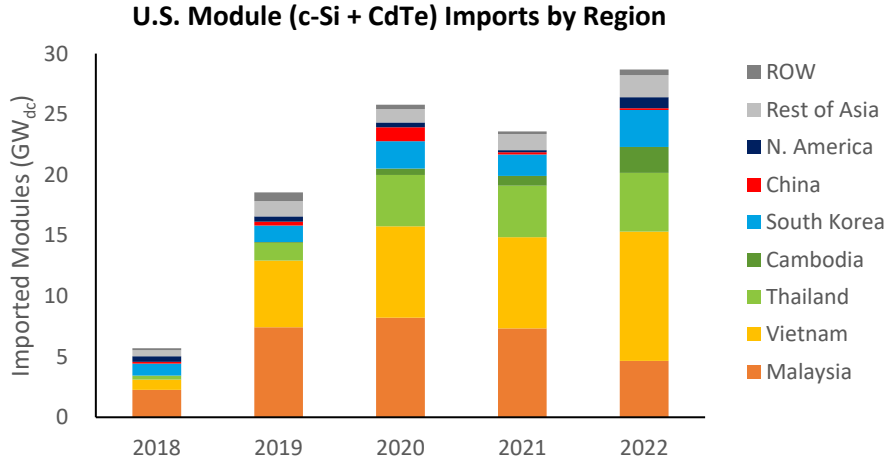
According to U.S. Census data, 2.5 GW_{dc} of cells were imported in 2022, a decrease of 7% y/y (178 MW).

- In 2022, Malaysia represented 62% of cell imports, up from only 27% in 2021. In contrast, South Korea fell to only 3% of annual imports in 2022 from 44% in 2021.
- Modules imports from South Korea grew by 1.3 GW between 2021 and 2022, which matches well with the 1.1 GW decrease of cell imports.

According to U.S. Census data, 28.7 GW_{dc} of modules were imported in 2022, an increase of 21% y/y (+5 GW).

- In 2022, 16% of modules were imported from Malaysia, 37% from Vietnam, 17% from Thailand, 7% from Cambodia for a total of 78% of all module imports (or 73% of c-Si modules) coming from the four countries under investigation for circumventing AD/CVD duties. Including cell imports, it's 75% of c-Si imports.
- An additional 11% of module imports from 2022 were from South Korea, and 4% were from either Canada or Mexico.



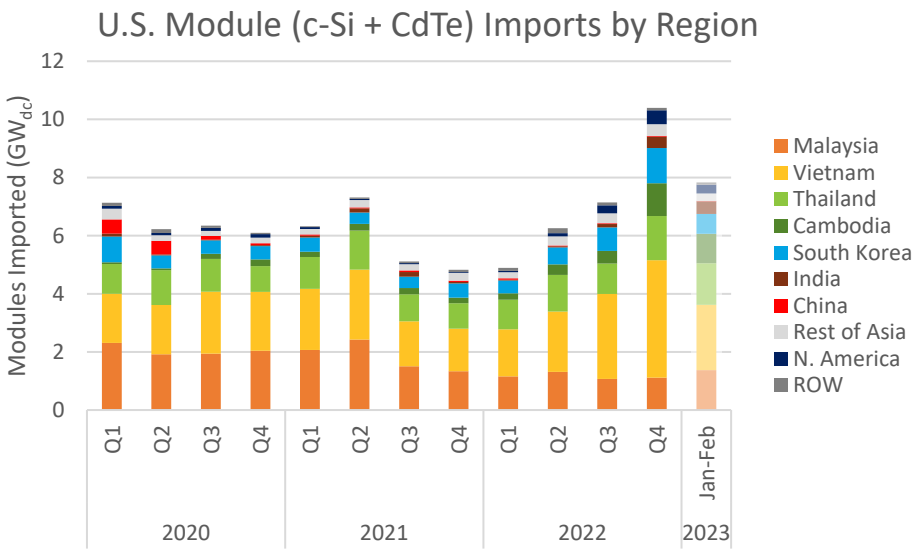


Sources: Imports by HTS code: 8541460015(2018-2021)/8541430010(2022-) and 8541460035(2018-2021)/8541430080(2022-), Second Quantity (watts) from the U.S. International Trade Commission DataWeb as well as the U.S. Census Bureau USA Trade Online tool and corrections page as of 4/11/23.

U.S. Module Imports by Region

According to U.S. Census data, in Q4 2022, U.S. module imports continued their upward trend (+46%, 3.25 GW_{dc} q/q), totaling 28.7 GW_{dc} in 2022 (+22% y/y, +5 GW_{dc}).

– As in Q2 and Q3, the Q4 increase was predominantly the result of increased imports from Vietnam (+38% q/q, +1.1 GW).



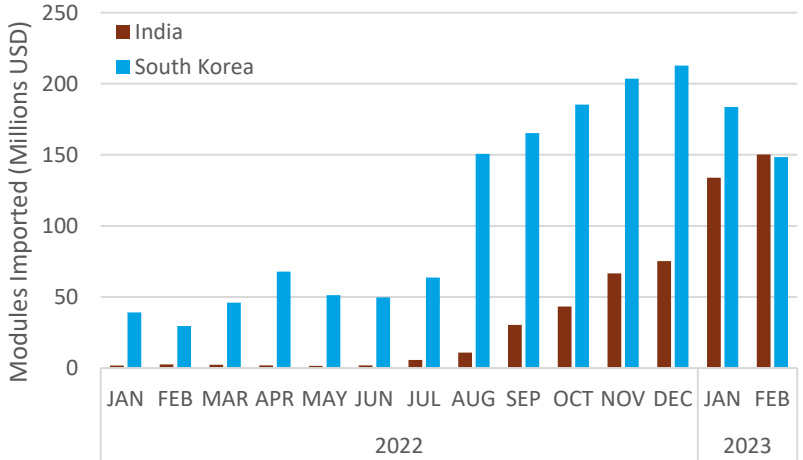
Though Q1 2023 is not yet complete, it has already surpassed Q3 2022 imports.

– This has been mainly the result of imports from Vietnam, which totaled nearly 2.2 GW (1.6 GW c-Si + 0.6 GW thin film) over January and February.

Imports from India and South Korea grew significantly in 2022.

– India imported ~$500M worth of modules over last 8 months, a 25-fold increase since July 2022. South Korean module imports nearly tripled over the same period.

– Canada and Mexico also experienced an increase in imports starting in mid-2022, accounting for nearly 5% of imports by value in Q4 2022.



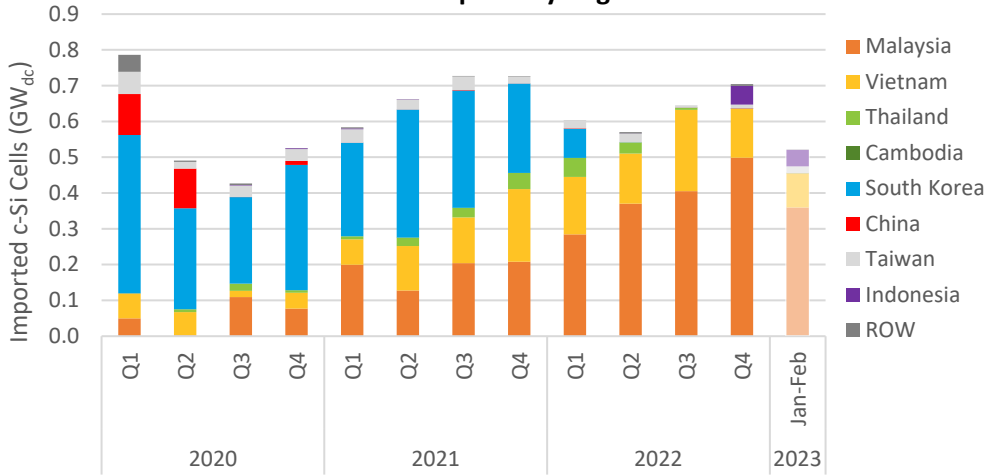
Sources: Imports by HTS code: 8541460015(2018-2021)/8541430010(2022-) and 8541460035(2018-2021)/8541430080(2022-), Second Quantity (watts) from the U.S. International Trade Commission DataWeb as well as the U.S. Census Bureau USA Trade Online tool and corrections page as of 4/11/23.

c-Si Cell Import Data Q1-Q4 2022

According to U.S. Census data, 2.5 GW_{dc} of cells were imported in 2022. Quarterly cell imports grew for the second quarter in a row in Q4 2022 (+60 MW_{dc}, +9% q/q).

- This growth was almost entirely the result of increased imports from Malaysia (500 MW in Q4 alone), which have been ramping up since Q2 2021.
- Indonesia was also responsible for 7% of imports in Q4 2022 (52 MW).

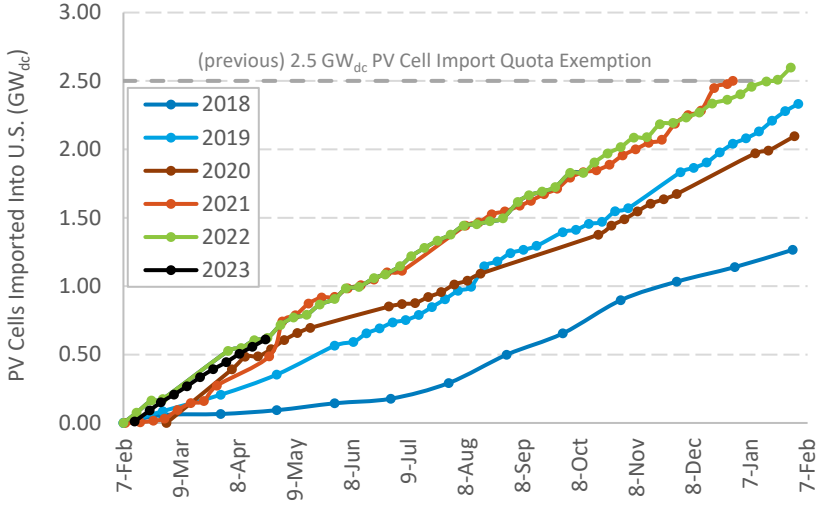
U.S. Cell Imports by Region



Though only January and February data are available, imports in Q1 2023 are on track to continue this growth.

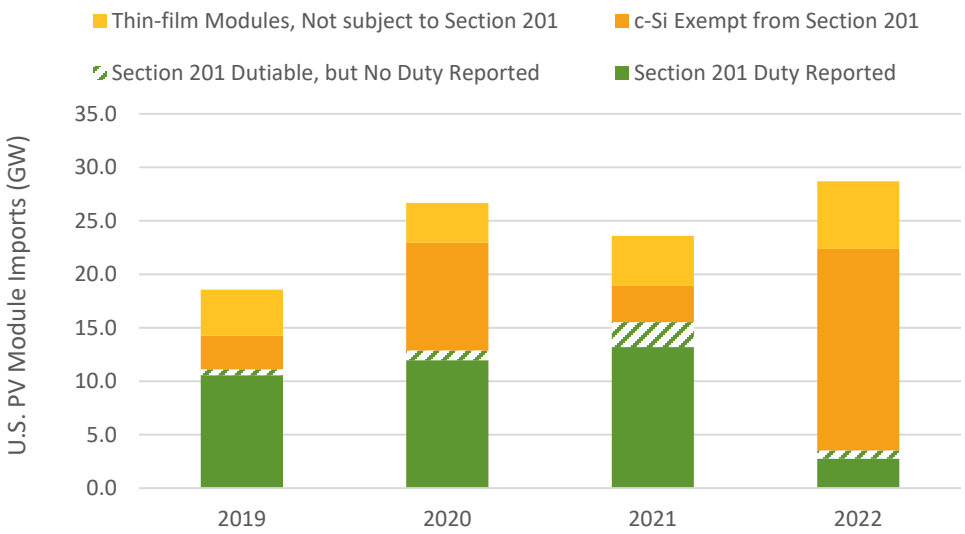
Indeed, according to CBP Commodity Status Reports, cell imports since February (the date the annual tariff rate quota for Section 201 Tariffs is counted from) are in-line with imports for the past two years. This is seemingly despite the new c-Si module capacity becoming operational in 2023.

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 4/11/23; U.S. Customs and Border Protection Commodity Status Reports February 2019–April 2023.

2022 U.S. Module Imports by Tariff



In 2022, only 10% (2.7 GW_{dc}) of modules reported a tariff, compared to 56% (13.2 GW_{dc}) in 2021.

- Most of the modules that did not were c-Si technology panels exempt from Section 201 tariffs (18.8 GW_{dc}, 65%) or thin-film and not subject to tariffs (6.3 GW_{dc}, 23%).

Over the course of 2022, c-Si modules went from reporting a tariff 25% of the time in Q1 to 11% in Q4.

- The c-Si imports were likely bifacial panels, which the Biden administration exempted from Section 201 duties in February 2022.

Thin-film modules accounted for 22% of module imports in 2022, up nearly 1.4 GW (+28% y/y) from 2021.

- 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.

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 85414030080. 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: HTS code 8541430010 Cambodia February 2022, HTS code 8541430080/8541430010 India July-December 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 4/11/23.

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
BIPV: building-integrated photovoltaics
c-Si: crystalline silicon
C&I: commercial and industrial
CC: combined cycle
CBP: U.S. Customs and Border Protection
CdTe: cadmium telluride
CIGS/CSI: copper indium gallium selenide
CPI: consumer price index
CPUC: California Public Utility Commission
CRA: Congressional Review Act
CSP: concentrating solar power
CT: combustion turbine
CVD: countervailing
dc: direct current
DPV: distributed photovoltaics
DOE: U.S. Department of Energy
EIA: U.S. Energy Information Administration
ETF: exchange traded fund
EU: European Union
GW: gigawatt
GWh: gigawatt-hour
H1: first half of year
H2: second half of year
HJT: heterojunction technology
HTS: harmonized tariff schedule
IEA: International Energy Agency
IOU: investor-owned utility
IRA: Inflation Reduction Act of 2022
IRS: Internal Revenue Service
IBC: interdigitated back contact
ITC: investment tax credit
kW: kilowatt
kWh: kilowatt-hour
LBNL: Lawrence Berkeley National Laboratory
MPTC: manufacturing production tax credit
MW: megawatt
MWh: megawatt-hour
NEM: net energy metering
NREL: National Renewable Energy Laboratory
PERC: passivated emitter and rear contact
PPA: power purchase agreement
PTC: production tax credit
PV: photovoltaics
Q: quarter
q/q: quarter over quarter
SEIA: Solar Energy Industries Association
SETO: Solar Energy Technology Office
TAN: Invesco Solar ETF
TOPCon: tunnel oxide passivated contact
TW: terawatt
TWh: terawatt-hour
UAE: United Arab Emirites
UFLPA: Uyghur Forced Labor Prevention Act
UPV: utility-scale photovoltaics
USD: U.S. dollars
VPP: virtual power plant
W: watt
Wt avg: weighted average
y/y: year over year
YTD: year to date

List of Manufacturing Announcements (page 1)

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)

List of Manufacturing Announcements (page 3)

FTC Solar, Taihua set up US-based JV to produce steel components (pv-tech.org)
This US solar company is about to ramp up flexible thin-film solar (electrek.co)
Ascent Solar - Ascent Solar Technologies, Inc. Announces First Step of Strategic Plan; Executes Term Sheet for Acquisition of Assets From Leading European Thin-Film Solar Manufacturer
Hounen Solar establishing first U.S. manufacturing operations in Orangeburg County | S.C. Governor Henry McMaster (sc.gov)
Another Chinese Company To Start PV Module Production in US | TaiyangNews
The factory comes as Ohio ramps up solar farm construction (dispatch.com)
Linton Crystal Technologies to produce solar ingot, wafer equipment in United States | Solar Builder (solarbuildermag.com)
India's Rayzon Solar to make TOPCon modules in US – PV magazine International (pv-magazine.com)
Silfab Solar to Execute First Phase of USA Cell Manufacturing
Solarcycle bags US$30 million to expand capacity (pv-tech.org)
Vitro Enters Agreement with First Solar to Manufacture Glass for Solar Panels - USGlass Magazine & USGNN Headline News