NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Summer 2023 Solar Industry Update

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August 3, 2023

Agenda

1. Global Solar Deployment
2. U.S. Policy Updates
3. U.S. PV Deployment
4. PV Pricing
5. Global Manufacturing
6. U.S. PV Imports
7. Virtual Power Plants

Executive Summary

U.S. Photovoltaic (PV) Deployment

- In Q2 2023, the Internal Revenue Service (IRS) released initial guidance on several key provisions within the Inflation Reduction Act, including: labor rules, bonus credits (1,2,3), direct payment, and transferability of the Investment Tax Credit (ITC) and Property Tax Credit (PTC), as well as the Advanced Energy Project Credit (48C).
- At the end of 2022, more than 263,000 U.S. employees spent most of their time on solar. An additional 82,250 workers spent less than half their time on solar-related work.
- The United States installed 5.7 GW_{ac} (6.1 GW_{dc}) of PV in Q1 2023—and the largest Q1 on record; a significant portion was in Texas, Florida, and California.
- 34% of U.S. utility-scale PV and ~21% of all U.S. PV systems built in 2022 used CdTe panels.
- The United States installed ~2.1 GWh (0.8 GWac) of energy storage onto the electric grid in Q1 2023.
- 89% of GWh of utility-scale battery storage installed in 2021 was co-located with an electric generation asset (or retired plant), however in 2022 that number dropped to 59%.

PV System and Component Pricing

- Global polysilicon spot prices dropped about 70% from mid-April to mid-July, reaching the $8/kg level for the first time in 3 years.
- Global module prices reached their lowest-ever point at $0.17/W because of oversupply, competition, decreasing module commodity (e.g., silver, aluminum) and freight prices, and a decline in the value of the yuan vs. the dollar—despite continued strong demand for modules worldwide.
- In Q2 2023 (first 2 months), the average U.S. module price ($0.37/$W_{dc}$) was up 2% q/q with no change y/y and modules trading at a 76% premium over the global spot price for monofacial monocrystalline silicon modules.
- LevelTen reports that after several years of rising prices, solar power purchase agreement (PPA) prices in the U.S. showed signs of stabilization in Q2.
- From H1 2022 to H1 2023, distributed PV system prices generally increased in nominal dollars but were down when accounting for inflation.

Global Manufacturing

- In Q1 2023, margins for most PV companies increased as demand increased, aided by a significant drop in polysilicon prices.
- Available data for 8 of the leading PV module suppliers found that Q1 2023 shipments were 61% higher than shipments from these companies in Q1 2022.
- Since the Inflation Reduction Act's (IRA's) passage, over 185 GW of U.S. manufacturing capacity has been announced across the solar supply chain, including 44 separate new manufacturing plants and 6 expansions.

U.S. PV Imports

- 12.2 GWdc of PV modules were imported into the United States in Q1 2023, +17% q/q and +149% y/y.
- 790 MW_{dc} of cells were imported in Q1 2023, up 13% q/q and 32% y/y.
- Despite the increase in PV cell imports in Q1 2023, as of May, PV cell imports are still on track to reach 2.5 GW_{dc} of the Section 201 quota despite the quota being raised to 5.0 GW_{dc} last year.

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

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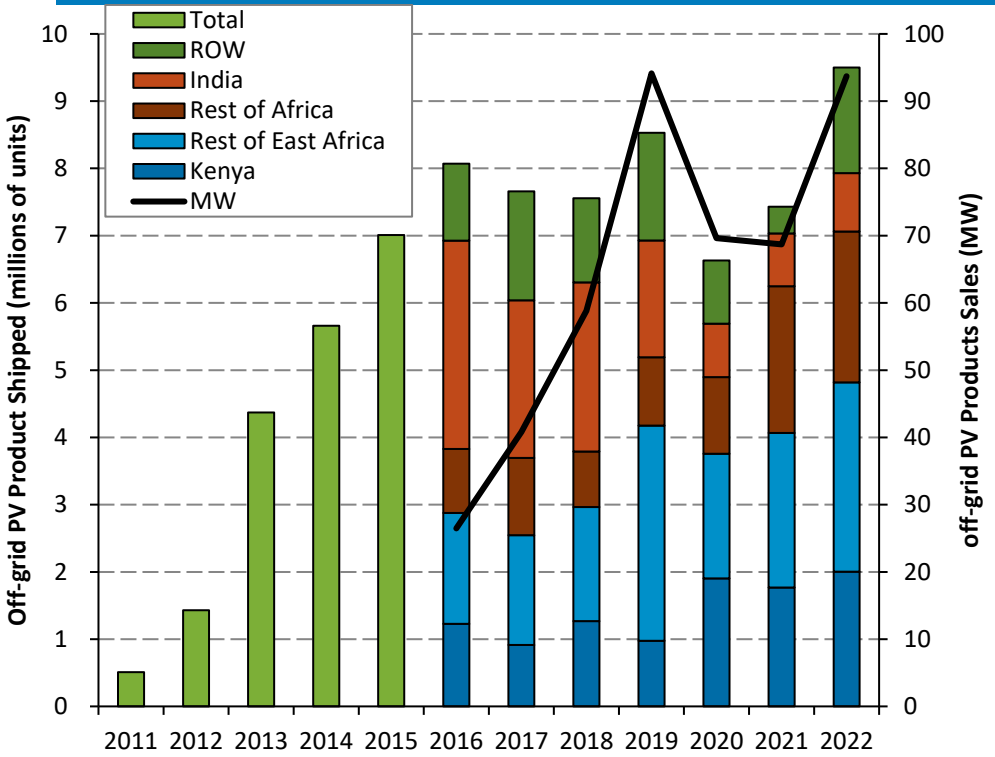
- **In 2022, after several years of stagnation caused by the COVID pandemic, a record 9.5 million off-grid solar products were sold in 2022. Collectively, they had a capacity of 94 MW.**
- **The first Spanish concentrated solar power (CSP) plant in a decade could be built this year after the central government approved the Environmental Impact Declaration. The 110 MW Solgest CSP plant is to be built along with 40 MW of PV.**

CSP Update

- In June 2023, Chile published draft rules for its 2023 energy auction which SolarPaces believes will incentivize dispatchable CSP. The auction includes incentives for non-variable renewables like CSP, a splitting of the auction into three geographic zones, an increase in contract length to 20 years, and may allow the transfer of systemic costs caused by short-term market factors.
- In June 2023, Heliogen announced its first solar thermal hydrogen customer – the city of Lancaster, California. Heliogen's Proxima plant, located in Lancaster, will provide the hydrogen. The plants will contain 1,000-2,000 heliostats and a 1.8 GWe Bloom Energy electrolyzer.
- The first Spanish CSP plant in a decade could be built this year after the central government approved the Environmental Impact Declaration. The 110 MW Solgest CSP plant is to be built along with 40 MW of PV.
- A Swiss team achieved a record solar-to-hydrogen device-level efficiency of greater than 20%, using a CSP parabolic dish. The device is already operational, and a start-up is commercializing the system to scale up the technology.

Global Off-Grid Solar Market



- Despite significant growth of off-grid PV in the first part of the last decade, sales started to stagnate in 2016 and then contracted from the COVID-19 pandemic.
- In 2022, these trends reversed, with the Global Off-Grid Lighting Association tracking a record 9.5 million off-grid solar products sold in 2022. Collectively, they had a capacity of 94 MW.
  - The association attributed the gains to better programmatic support, and improved financial mechanisms.
  - Most of the units sold were associated with lighting (particularly by volume portable lighting products), however preliminary data shows almost 2 million in products associated with appliances, including fans, TVs, radios, water pumps, and refrigerators.

Source: Global Off-Grid Lighting Association, "Global Off-Grid Solar Market Report Semi-Annual Sales and Impact Data."

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- **In Q2 2023, the IRS released initial guidance on several key provisions within the Inflation Reduction Act, including: bonus credits, direct payment, and transferability of the ITC and PTC.**
- **On June 28th, the U.S. Environmental Protection Agency (EPA) released a Notice of Funding Opportunity for the $7 billion Solar for All grant program through the Greenhouse Gas Reduction Fund (GGRF).**
- **In Q2 2023, the California Independent System Operator approved a $7.3 billion plan to build transmission connecting 17+ GW of solar capacity.**

States: Q2 2023 Updates

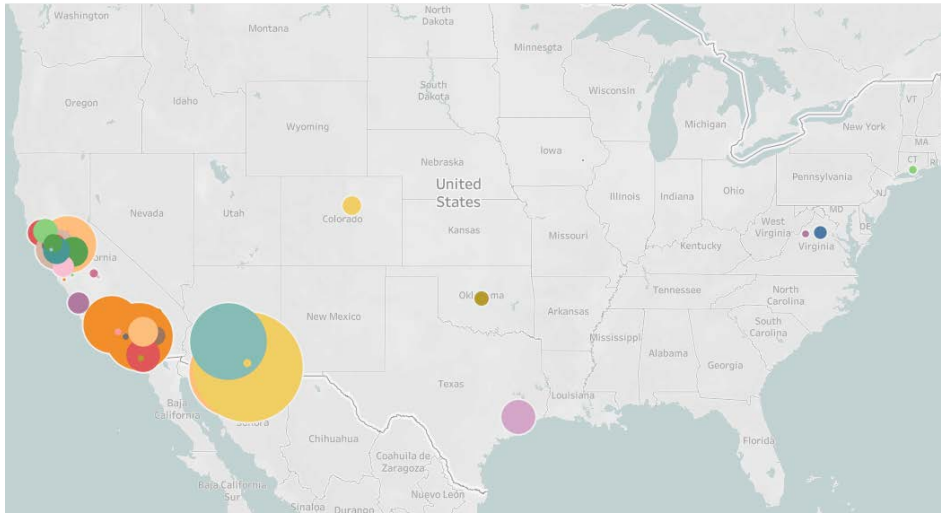
Map shows locations (58) using SolarAPP+ as of July 14, 2023. Symbol sizes scale to capacity of PV approved using SolarAPP+ (23,600 permits, 142 MW total).

Total kW Approved
0
10,000
20,000
34,001

Colorado created a million-dollar grant program to help local governments start using permitting and inspection software such as SolarAPP+.

After passing a 100% clean power law in Q1, **Minnesota** passed laws in Q2 including funding PV on public buildings, grid upgrades, energy storage, utility PV incentives, electrification, green banks, and PV recycling studies while expanding community solar, requiring utilities to procure distributed PV, and protecting residential PV customers from HOA restrictions.

The **California** Independent System Operator approved a $7.3 billion plan to build transmission connecting 17+ GW of solar capacity and 9+ GW of wind and geothermal capacity by 2030, aiming to coordinate transmission and generator locations and reduce interconnection delays.



Vermont enacted a clean heat standard to reduce fossil heating.

New York passed the first statewide ban on natural gas in new buildings and authorized publicly funded, constructed, and owned renewable energy projects.

Maryland expanded and made permanent its community solar program, becoming the 23rd state to have a community solar framework without access limits.

Texas passed a law requiring renewable energy projects to pay higher transmission fees and pay for "firming" requirements but avoiding strong restrictions on renewable energy permitting from the original bill.

Sources: Canary Media (5/3/23, 5/11/23, 5/16/23, 5/22/23, 5/24/23), PV Magazine (5/2/23, 5/17/23, 5/25/23, 5/30/23), PV Tech (5/24/23), Reuters (6/23/23), SolarAPP+ (accessed 7/20/23), Solar Power World (4/18/23, 5/23/23)

Solar Tax Credit Summary and Status

Tax Credit	Value	End Year	Treasury Initial Guidance
Advanced Manufacturing Production Tax Credit (MPTC, 45X)	Varies by component	2032	[none yet]
Advanced Energy Project Credit (48C)‡	30% ($10B total)	N/A	Additional Guidance from IRS/MESC
Production Tax Credit (PTC, 45(d)/45Y)‡	2.75 ¢/kWh† + bonus	2035*	Labor Rules Energy Communities Bonus Low-Income Community Bonus Domestic Content Bonus
Investment Tax Credit (ITC, 48/48E)‡	30% + bonus	2035*	
Residential Clean Energy Credit (25D)	30%	2033	FAQs on energy efficient home improvements and 25D
‡Values could be reduced by a factor of 5 for facilities ≥ 1 MW_{ac} that fail to meet labor rules	†Adjusted for inflation	*could be extended	Direct Pay and Transferability, including FAQs

Advanced Energy Project Credit (48C) Newest Guidance

On May 31st, Treasury and the IRS released further guidance on the 48C tax credit allocation process. Administered by the U.S. Department of Energy's (DOE's) Office of Manufacturing and Energy Supply Chains (MESC), 48C awards an upfront 30% tax credit (if labor requirements are met) for capital investments made to purchase and commission or upgrade an industrial, manufacturing, or recycling facility. MESC also held an informational webinar on June 27, 2023

As detailed in the initial guidance issued in February, selection will follow the standard DOE two-step funding opportunity announcement (FOA) process of concept papers which receive encourage/discourage letters, followed by review of a full application. The program will begin accepting concept papers on June 30, 2023 via eXCHANGE, for a first round of $4 billion in credits, with approximately $1.6 billion reserved for projects in eligible communities (see map). Concept papers will be due no later than July 31, 2023. Encourage/discourage letters are anticipated in the fall of 2023. The deadline for full applications has not yet been set. Decisions will be made by March 31, 2024.

Projects will be evaluated first for compliance and eligibility and then evaluated based on the following 4 technical criteria:

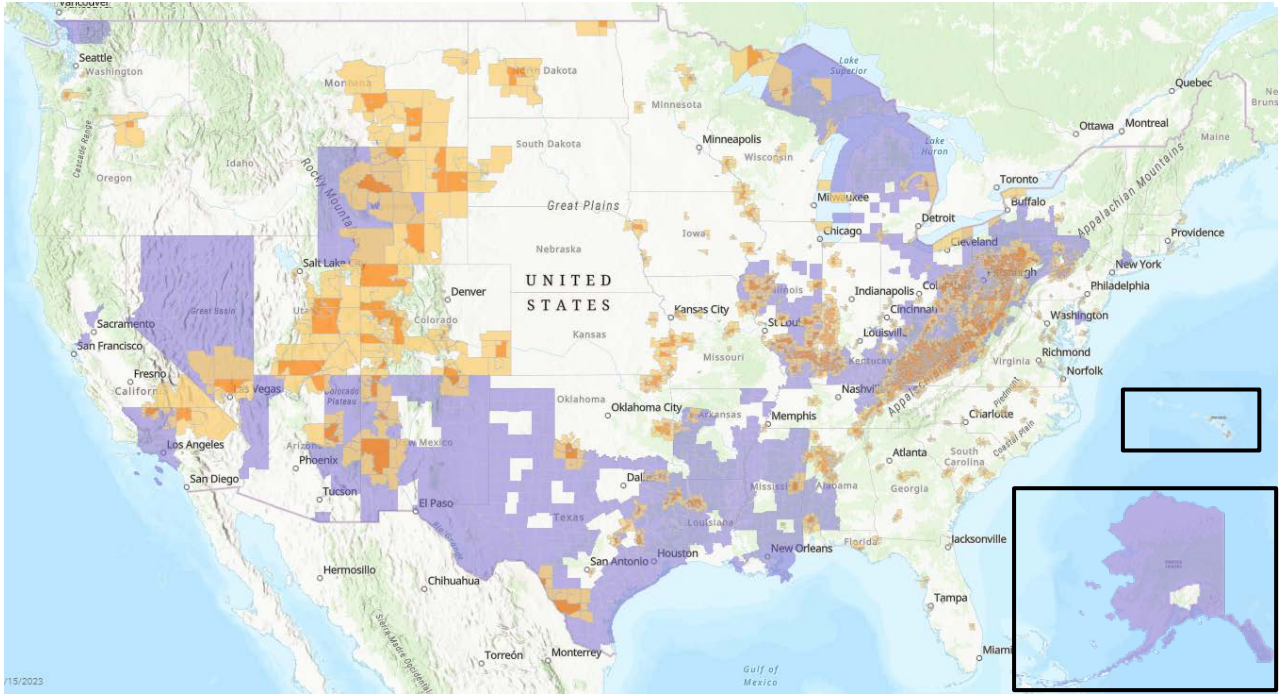
1. Commercial viability (including shortest project timeline, lowest levelized cost of energy (LCOE), and risk mitigation strategies)
2. Net impact on greenhouse gas reduction (including direct, indirect, and lifecycle emissions)
3. Strengthening U.S. supply chains (Round 1 priority areas are: polysilicon, wafer, ingot/wafer production tools, and solar glass)
4. Workforce and community engagement (a plan for this must be included in both application stages)

DOE will also rank the applications based on program policy factors such as portfolio diversity (size, technology, geography, etc.).

Projects may not be placed in service prior to allocation. Once allocated, projects must be certified within 2 years and place in service within 2 years of certification. Taxpayers must inform DOE and the IRS of any significant change of plans.

Energy Communities Bonus Newest Guidance

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. They updated both map and guidance on June 15th, as well as adding an FAQs page. From 2024 on, the map should be updated each May.



- Coal Closure Community
- Adjacent to a Coal Closure Community
- Metropolitan or Non-Metropolitan Statistical Areas that meet the Fossil Fuel Employment Threshold and the unemployment rate requirement

Not depicted:

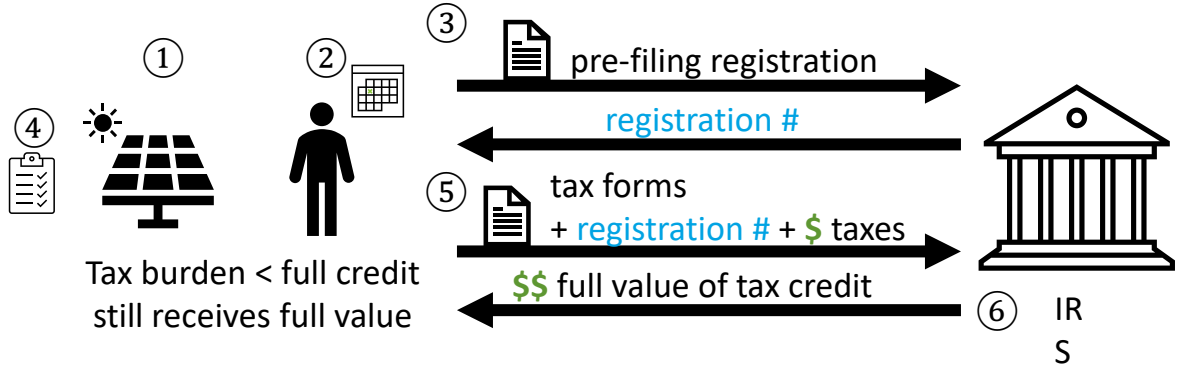
- Brownfields
  (≠ EPA Brownfield Program Sites)
- Fossil fuel communities as determined based on tax revenue.

Grandfather clause* only applies to facilities constructed in/after 2023.

*Grandfather clause: if a project starts construction on a site located in a fossil fuel community, it will still receive the credit if the status of the community changes in a later year.

Direct Payment of Tax Credits Guidance

Treasury and the IRS have issued FAQs, proposed, and temporary regulations on direct pay (also called "elective pay") of the ITC, PTC, 48C, and Manufacturing Production Tax Credit (MPTC). Comments were due to the IRS by August 14th.



Step ① - Pursue a qualifying project

Step ② - Determine the tax year

Step ③ - Complete pre-filing registration with the IRS and get #

Step ④ - Meet all requirements of qualifying project

Step ⑤ - File annual taxes using #

Step ⑥ - Get refund

Not all steps need be sequential, but ③ must precede ⑤ and ⑥.

The ITC, PTC, and 48C are eligible for direct pay only by:

- Tax-exempt organizations
- States and Territories (or political subdivisions thereof, including cities, counties, and instrumentalities like school districts)
- Indian tribal governments
- Alaska Native Corporations
- The Tennessee Valley Authority
- Rural electric cooperatives.

The MPTC is eligible for direct pay for five consecutive years (which may be postponed).

Direct Payment of Tax Credits Guidance

Treasury and the IRS have issued FAQs, proposed, and temporary regulations on direct pay of the ITC, PTC, 48C, and MPTC. Comments were due to the IRS by August 14th. The FAQs for direct pay also clarified:

- Which entities were eligible for direct pay (including instrumentalities and agencies of States, cities, and counties like school districts, economic development agencies, or public hospitals)
- What ownership structures are allowed for direct pay under the ITC, PTC, or 48C (e.g., a tenancy-in-common arrangement is allowed, but a partnership, if even if all partners are eligible, is not) and the MPTC (partnerships and S corporations are allowed)
- How tax-exempt income affects the direct pay math (it can be included in the basis, but the total direct pay amount cannot exceed the [project cost – tax-exempt funds that were granted specifically for this project])
- That transfer credits are ineligible for direct pay.

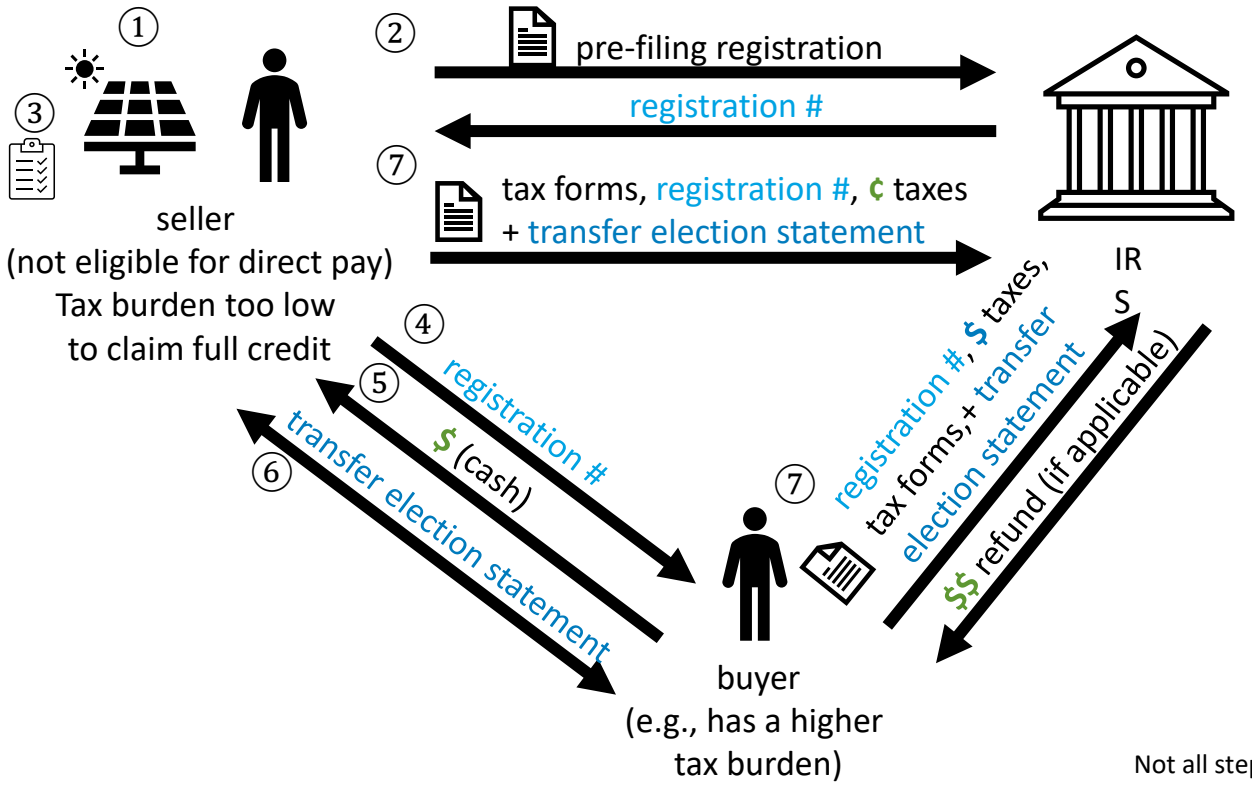
As outlined on the previous slide, the FAQs also described the process of electing direct pay. More information about (electronic) pre-filing registration will be available when the process is launched later in 2023, including advice for filers without internet access. Registration is required every year (even for elections that last multiple years, such as the PTC) and for each applicable property but does not confirm eligibility.

Direct pay can only be made on original, timely filed returns (including extensions), and payments occur after the return is processed. Elective payment is irrevocable for the ITC, PTC, and 48C.

More guidance is still to come (including domestic content requirements of direct pay starting in 2024).

Transferability of Tax Credits Guidance

Treasury and the IRS have issued FAQs, proposed, and temporary regulations on the transferability of the MPTC, 48C, ITC and PTC. Comments were due to the IRS by August 14th.



Step ① - Pursue a qualifying project

Step ② - Complete pre-filing registration with the IRS and get #

Step ③ - Meet all requirements of qualifying project to earn credit

Step ④ - Arrange to transfer the credit to an unrelated buyer for cash

Step ⑤ - Provide the buyer the #

Step ⑥ - Complete the transfer election statement with the buyer

Step ⑦ - Both buyer and seller file annual taxes including the transfer election statement and registration number

Not all steps need be sequential, but ② must precede ⑤- ⑦.

Transferability of Tax Credits Guidance

Treasury and the IRS have issued FAQs, proposed, and temporary regulations on the transferability of the MPTC, 48C, ITC and PTC. Comments were due to the IRS by August 14th.

The FAQs for transferability also clarified that:

- A taxpayer cannot transfer just the bonus credit amount of a credit
- Credit from a single property can be sold to multiple (unrelated) buyers in the same tax year
- Buyers can incorporate transferred credits in their estimated taxes
- The buyer bears responsibility for recapture
- Depreciation benefits do not transfer
- Transfer credits are ineligible for direct pay.

As outlined on the previous slide, the FAQs also described the transfer process. More information about (electronic) pre-filing registration will be available when the process is launched later in 2023. Registration is required every year and for each applicable property but does not confirm eligibility.

If the credits from a single property have multiple buyers, the same registration # is used.

Sellers attach the transfer election statement to the tax return in the year in which they become entitled to the credit. Buyers do so in the year in which they take the credit into account.

Domestic Content Bonus Guidance

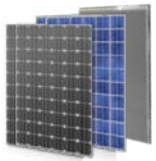
Treasury and the IRS have issued initial guidance on the 10% domestic content bonus credit available for the ITC or PTC which will apply until 90 days after the date of publication of forthcoming proposed regulations.

The guidance clarified relevant definitions and provided a non-exhaustive list of utility-scale solar PV products:

Applicable Project

Manufactured Products

A set percentage of the total direct costs† of all manufactured products must be U.S.-made.



Module

Components*
Cells, Frame, Glass, Encapsulant, Junction Box, Backsheet, Edge Seals, Pottants, Bus Ribbons, Adhesives, Bypass Diodes

Tracker

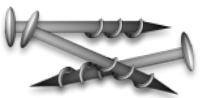
Inverter

*sourcing of subcomponents (e.g., wafers) is not constrained

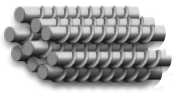
Steel and Iron Products

All structural steel or iron products must be U.S.-made

Racking



Pile/ground screw



Rebar

$$\text{Domestic Cost Percentage} = \frac{\text{U.S. Manufactured Products Costs + Eligible U.S. Components Costs}}{\text{Total Manufactured Products Costs}} =$$

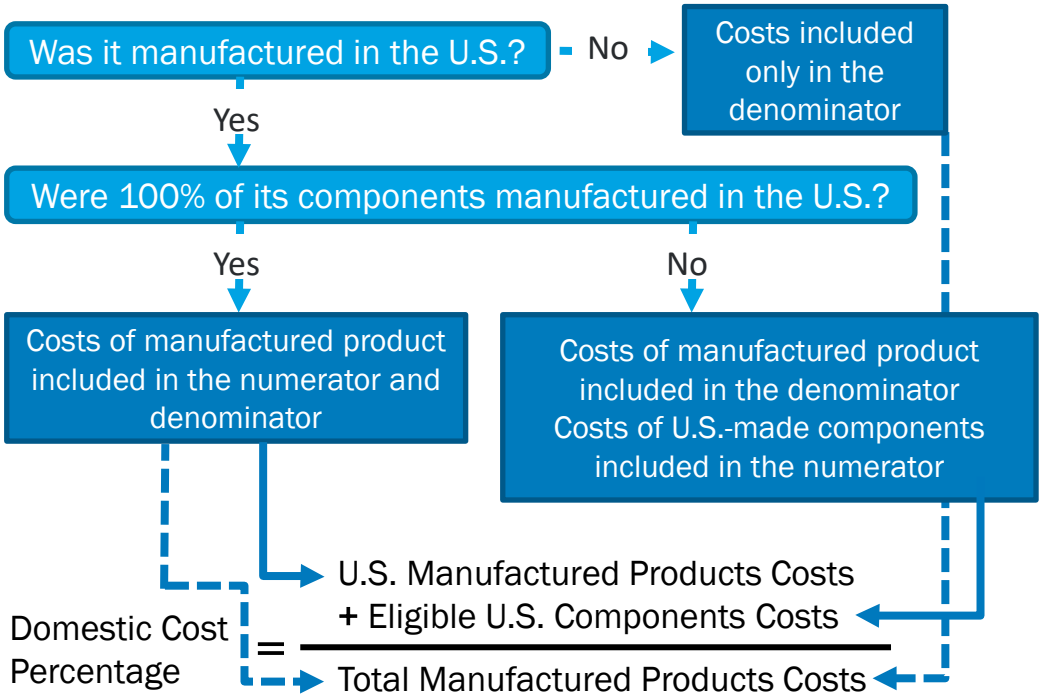
2023-2024	2025	2026	2027+
40%	45%	50%	55%

Taxpayers must attach a domestic content certification statement attesting they have met both requirements.

† Direct costs include only direct labor and material. The direct labor of products manufactured in the U.S. is only considered domestic if all of the components of the product are of U.S. origin.

Domestic Content Bonus Guidance

There are two questions which determine how the costs of a manufactured product are included in the calculation of the Domestic Cost Percentage.



Example:

20 x **Module A**

Tracker B

Inverter C

Manufacturing location		
Total	$10	
Component 1	$3	
Component 2	$4.50	

Total	$200	
Component 1	$50	
Component 2	$135	

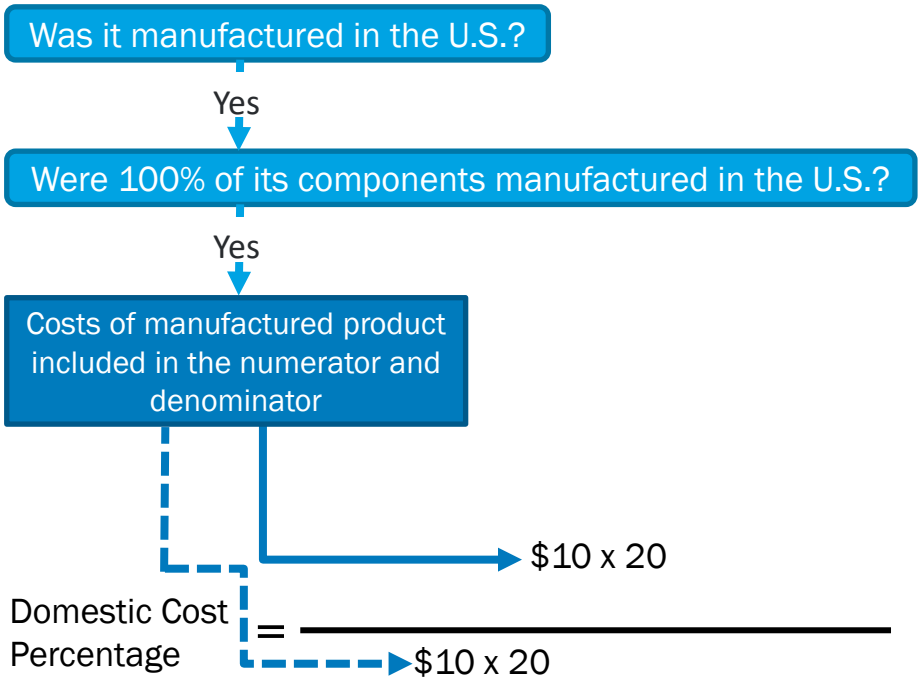
Total	$100	
Component 1	$20	
Component 2	$25	

All direct costs, but only direct costs are included in the computation (*not prices!*).

† Direct costs include only direct labor and material.

Domestic Content Bonus Guidance

There are two questions which determine how the costs of a manufactured product are included in the calculation of the Domestic Cost Percentage.



Example:

20 x Module A

		Manufacturing location
Total	$10	
Component 1	$3	
Component 2	$4.50	

Tracker B

Total	$200	
Component 1	$50	
Component 2	$135	

Inverter C

Total	$100	
Component 1	$20	
Component 2	$25	

Domestic Content Bonus Guidance

There are two questions which determine how the costs of a manufactured product are included in the calculation of the Domestic Cost Percentage.

Was it manufactured in the U.S.?

Yes

Were 100% of its components manufactured in the U.S.?

No

Costs of manufactured product included in the denominator
Costs of U.S.-made components included in the numerator

$$\text{Domestic Cost Percentage} = \frac{\$10 \times 20 + \$50}{\$10 \times 20 + \$200}$$

Example:

20 x Module A

Tracker B

Inverter C

Manufacturing location

Total	$10
Component 1	$3
Component 2	$4.50

Total	$200
Component 1	$50
Component 2	$135

Total	$100
Component 1	$20
Component 2	$25

Domestic Content Bonus Guidance

There are two questions which determine how the costs of a manufactured product are included in the calculation of the Domestic Cost Percentage.

Was it manufactured in the U.S.? - No → **Costs included only in the denominator**

$$\text{Domestic Cost Percentage} = \frac{\$10 \times 20 + \$50}{\$10 \times 20 + \$200 + \$100}$$

Example:

20 x **Module A**

		Manufacturing location
Total	$10	
Component 1	$3	
Component 2	$4.50	

Tracker B

Total	$200	
Component 1	$50	
Component 2	$135	

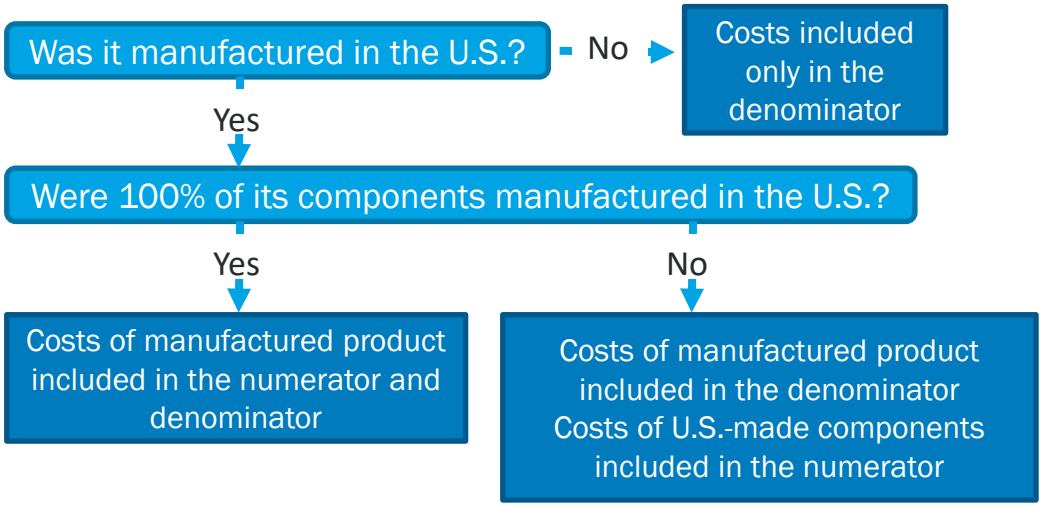
Inverter C

Total	$100	
Component 1	$20	
Component 2	$25	

U.S.-made components do not change the computations for foreign-manufactured products

Domestic Content Bonus Guidance

There are two questions which determine how the costs of a manufactured product are included in the calculation of the Domestic Cost Percentage.



Example:

Manufacturing location

20 x

Module A

Total	$10
Component 1	$3
Component 2	$4.50

Tracker B

Total	$200
Component 1	$50
Component 2	$135

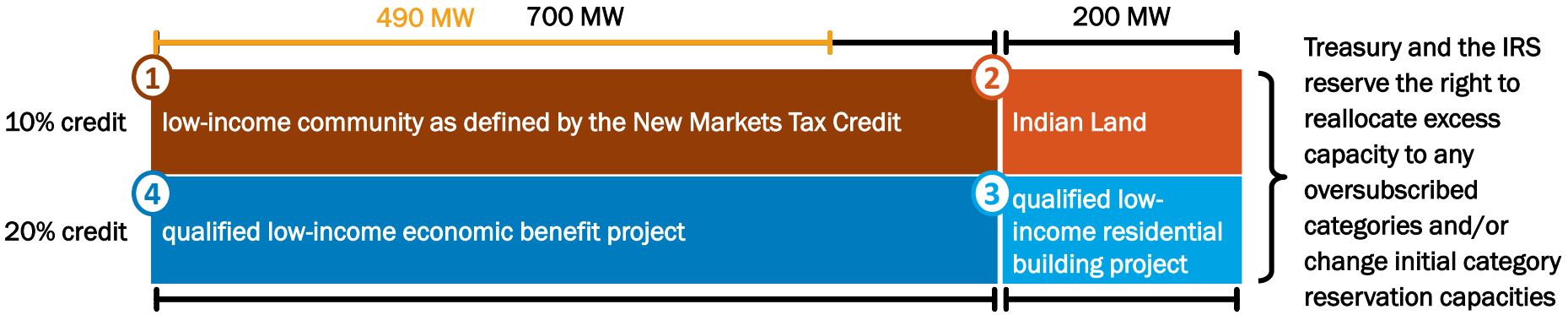
Inverter C

Total	$100
Component 1	$20
Component 2	$25

$$\text{Domestic Cost Percentage} = \frac{\$10 \times 20 + \$50}{\$10 \times 20 + \$200 + \$100} = 50\%$$

Low-Income Communities Bonus Newest Guidance

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 posted initial guidance in February and final regulations for 2023 awards in August, largely in line with Notice of Proposed Rulemaking released in June.



Treasury and the IRS clarified: how energy storage technology can be included*, how financial benefits for Category 3 & 4 projects would be calculated and distributed (including requiring Category 4 applicants provide at least a 20% bill credit discount rate for all low-income households), and how IRS intends to prevent circumvention of the rules (e.g., artificially dividing up projects; changing project size, location, ownership, or benefits distributions after allocation; placing a project in service prior to allocation).

Due to anticipated applications, and to better serve households in low-income areas, 490 MW of Category 1 is being allocated to residential behind-the-meter facilities for 2023 allocations, with the remainder reserved for front of the meter facilities and non-residential behind the meter facilities.

*Storage is not included in any project capacity limits; however, it must be owned by the same party, be on the same or contiguous land, and receive the same permitting and interconnection as the solar asset. Additionally, the owner must be able to provide that it is charged no less than 50 percent by the solar asset (a safe harbor applies if the power rating of the storage is less than 2 times the DC capacity of the solar facility).

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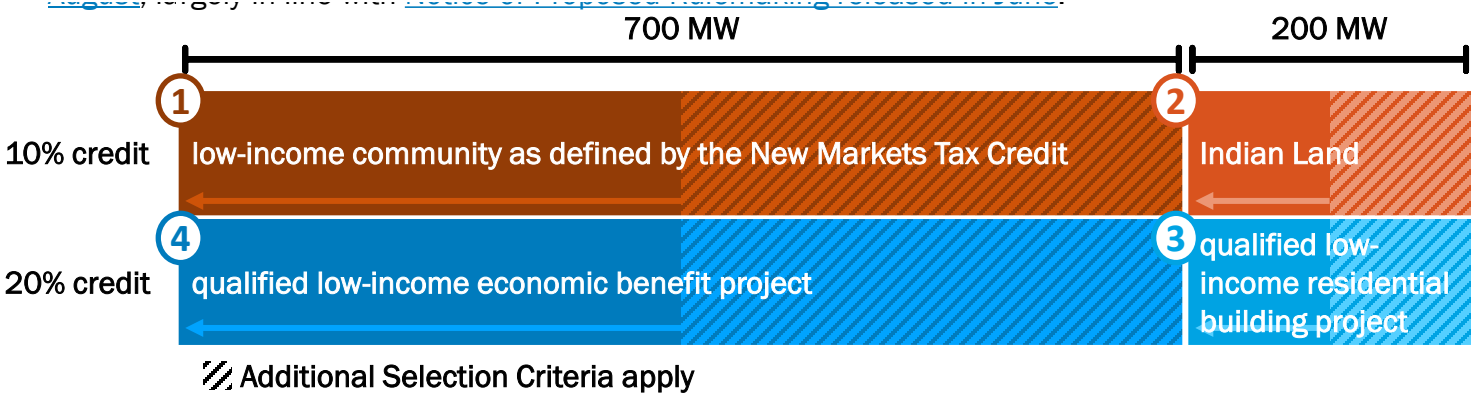
Low-Income Communities Bonus Credit Program (48(e)), awards an upfront 10% or 20% bonus tax credit for a maximum of 1.8 GW_{dc} per year of solar projects < 5 MW_{ac} in size. Treasury posted initial guidance in February and final regulations for 2023 awards in August, largely in line with Notice of Proposed Rulemaking released in June.



30-day application period in which all applicants receive the same time stamp.

Then, a rolling process if under allocation, a lottery process if over allocation.

Priority will be given to Additional Selection Criteria applications.

Treasury has also decided on two Additional Selection Criteria. At least 50% of each category will be reserved to projects that meet at least one of the additional criteria (priority will be given to applications meeting both criteria):

1. **Owned by** a Tribal enterprise or Alaska Native Corporation, renewable energy cooperative (where 51% of owners are low-income households), qualified renewable energy company (an entity serving low-income communities and provides pathways for clean energy adoption for those households), or a tax-exempt entity (including states, tribes, and rural electric co-ops).
2. **Located in** a Persistent Poverty county (where more than 20% of the population have experienced high rates of poverty over the past 30 years) or census tracts designated in the Climate and Economic Justice Screening Tool (CEJST) as disadvantaged in terms of energy burden, $PM_{2.5}$ exposure, and income.

Low-Income Communities Bonus Newest Guidance

Category	Type	Details
All	Attestation	All permits obtained
		Applicant is in compliance with all laws (including consumer protection)
		Applicant has inspected site for suitability
		Consumer disclosures have been/will be provided to customers
		Applicant has appropriately sized the facility
		*Facility meets Geographic criteria (Category 2 is exempt)
		Ownership/facility changes since application or lack thereof
	Document	Verification of site control (for FTM, only attestation is required)
		Executed interconnection agreement, if applicable. If not, other authorizations or affidavits required (for BTM ≤ 1 MW_{ac}, not required)
		Executed contract to purchase or lease facility or an executed PPA (BTM)
		*Verification applicant meets Ownership criteria
		Permission to Operate (PTO) letter or commissioning report for off-grid
		Verification of as-built nameplate capacity
1+2	Attestation	Facility location is eligible
3	Document	Proof residential building is eligible
		Plan to ensure tenants receive financial benefits
		Benefits Sharing Agreement
4	Attestation	Applicant will ensure 50% of financial benefits and 20% bill credit discount requirement is met
	Document	*Detailed final list of households or other entities served*
		Spreadsheet demonstrating 20% bill credit discount requirement met

*Only applies if applicant is applying under Additional Selection Criteria. FTM = front of the meter, BTM = behind the meter

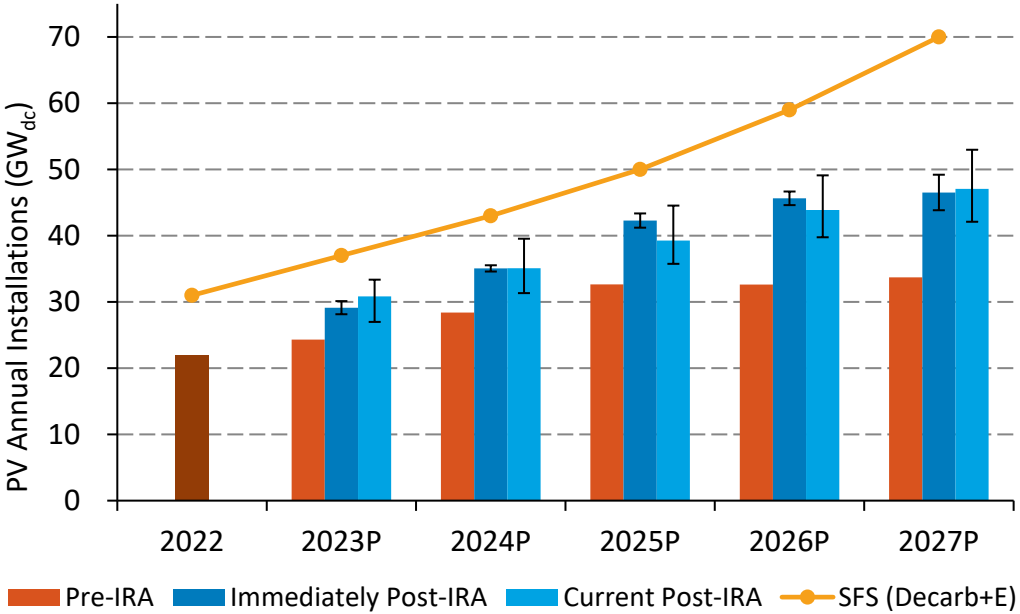
Treasury and the IRS described the application materials required and the materials required once a facility has been placed in service (*italicized*). The owner of the facility must be the one to apply.

Post-allocation, a facility cannot:

- Change location
- Change size (to be ≥5 MW_{ac} or by decreasing by the larger of 25% or 2 kW)
- Fail to meet "financial benefits" requirements
- Fail to meet ownership requirements, unless the original owner had the right of first refusal to purchase plant after the recapture period.

A facility also cannot be placed in service prior to allocation.

IRA-Induced Growth Projections



Notes: P = projection. Colored bars represent average projections, and error bars represent high and low projections, line is the decarbonization with electrification scenario from the Solar Futures Study (SFS).
Sources: BNEF, 2Q 2022 Global PV Market Outlook, 5/27/22; BNEF, 2Q 2023 Global PV Market Outlook, 8/26/22; BNEF 2Q 2023 Global PV Market Outlook, 5/23/23, Wood Mackenzie and SEIA, Q2 2022 US Solar Market Insight, 6/22; Wood Mackenzie and SEIA, Q3 2022 US Solar Market Insight, 9/22; Wood Mackenzie and SEIA, Q2 2023 US Solar Market Insight, 6/23. U.S. Department of Energy, Solar Futures Study, 9/21.

Before IRA, according to projections by BloombergNEF and Wood Mackenzie/Solar Energy Industry Association (SEIA), annual PV installations were expected to increase to 33 GW_{dc} in 2025 (~19% annual growth over three years) and then level off, reaching only 34 GW in 2027.

Immediately after IRA, projections from those two sources increased by ~30% per year, reaching 47 GW_{dc} in 2027.

Since then, projections have stayed approximately the same, as CA net energy metering (NEM) 3.0 and higher interest rates have downgraded residential solar projections and interconnection queue delays and decreases in the expected cost-competitiveness for solar against other technologies has impacted utility-scale solar projections. Increased clarity on various IRA regulations has not markedly increased or decreased projections.

Greenhouse Gas Reduction Fund Notices of Funding Opportunities

On June 28th, EPA released a Notice of Funding Opportunity for the $7 billion Solar for All grant program through the Greenhouse Gas Reduction Fund (GGRF). The program will award up to 60 grants to states, territories, Tribal governments, municipalities, and eligible non-profits to create and expand low-income solar programs that provide financing and technical assistance (including workforce development) to enable low-income and disadvantaged communities to deploy and benefit from residential solar.

There are three program sizes: small ($25-$100 million), medium ($100-$250 million), and large ($250-$400 million). Applicants can submit separate applications to one or multiple of the three options. Coalitions led by an eligible applicant may apply. There are three award options:

1. State and Territory Programs
2. American Indian and Alaska Native Programs
3. Multi-state Programs for similar communities facing similar barriers to residential distributed solar deployment in multiple states

All applicants are required to submit a Notice of Intent, the deadline for which varies by region:

- July 31, 2023 for states, the District of Columbia, and Puerto Rico
- August 14, 2023 for territories, municipalities, and eligible non-profits,
- August 28, 2023 for Tribal governments and Intertribal Consortia.

The deadline to apply for the program is September 26, 2023. A public briefing was held on July 12th.

The GGRF also saw the launches of the National Clean Investment Fund ($14 billion) and Clean Communities Investment Accelerator ($6 billion) on July 14th which will support 2-3 national non-profit clean financing institutions and 2-7 hub non-profits which will build the clean financing capacity of local community lenders working in low-income and disadvantaged communities, respectively.

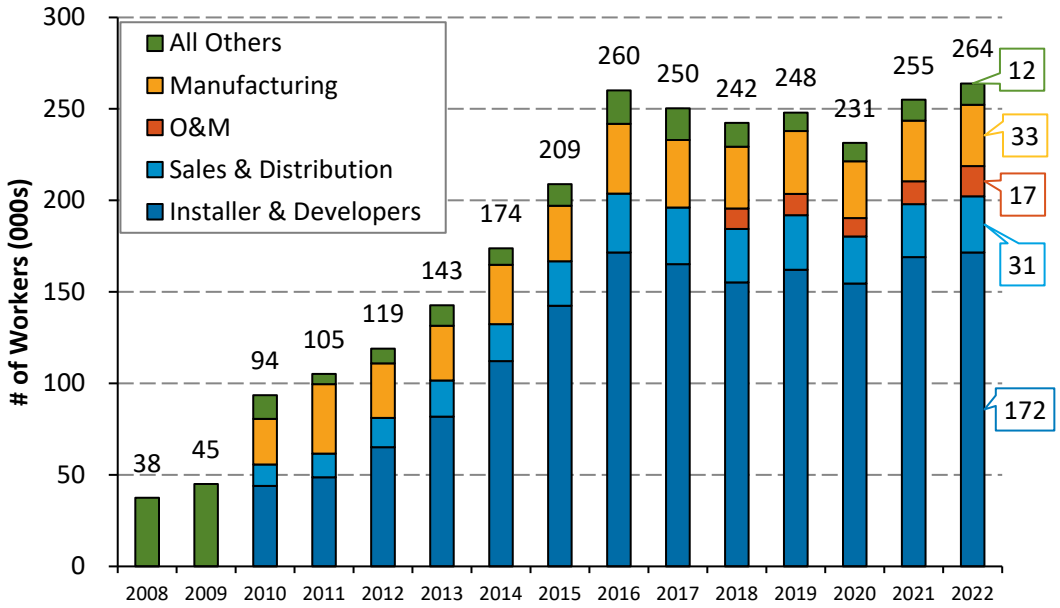
Agenda

1. Global Solar Deployment
2. U.S. Policy Updates
3. **U.S. PV Deployment**
4. PV Pricing
5. Global Manufacturing
6. U.S. PV Imports
7. Virtual Power Plants

- **At the end of 2022, more than 263,000 U.S. employees spent most of their time on solar. An additional 82,250 workers spent less than half their time on solar-related work.**
- **The United States installed 5.7 GW_{ac} (6.1 GW_{dc}) of PV in Q1 2023—and the largest Q1 on record; a significant portion was in Texas, Florida, and California.**
- **34% of U.S. utility-scale PV and ~21% of all U.S. PV systems built in 2022 used CdTe panels.**
- **The United States installed ~2.1 GWh (0.8 GW_{ac}) of energy storage onto the electric grid in Q1 2023.**
- **89% of GWh of utility-scale battery storage installed in 2021 was co-located with an electric generation asset (or retired plant), however in 2022 that number dropped to 59%.**

U.S. Solar Workforce (IREC)

- At the end of 2022, more than 263,000 U.S. employees spent most of their time on solar. An additional 82,250 workers spent less than half their time on solar-related work.

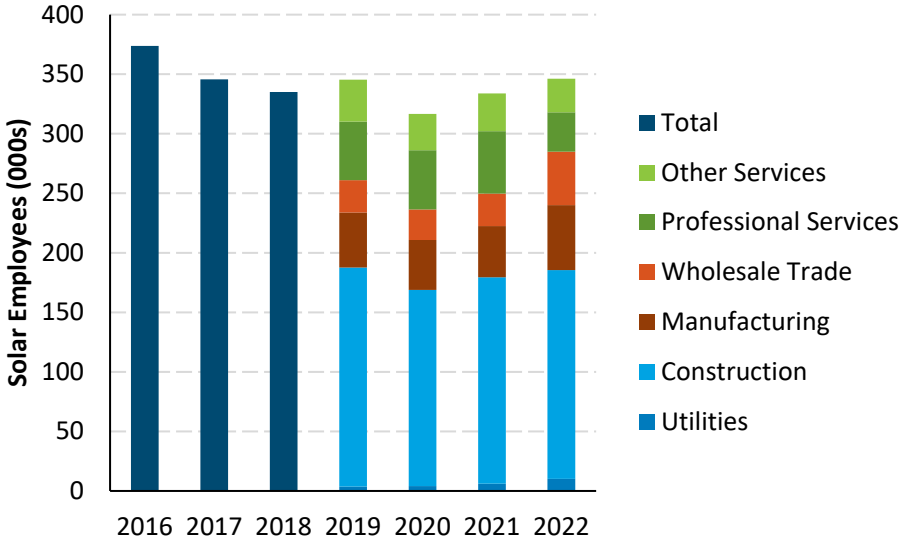


Source. IREC, The National Solar Jobs Census 2022. July 2023.

- This represents an increase of 8,846 jobs, or 3.5% growth since 2021.
  - Nationwide, the utility-scale solar market lost about 6,000 jobs in 2022. In contrast, residential solar jobs grew by 11%, or about 9,500 jobs, balancing out the losses in utility-scale solar.
- Solar jobs grew in 42 states and Puerto Rico in 2022. California added the most jobs in 2022 (+2,404 jobs), followed by New York (+988 jobs), Texas (+904 jobs), Florida (+506 jobs) and Massachusetts (+476 jobs).
  - However, 44% of solar industry employers said it was "very difficult" to find qualified applicants, a record high percentage.
- The proportion of women in the solar workforce increased from 27% in 2017 to 31% in 2022. Black people made up 9% of the solar workforce in 2022, considerably less than the proportion in the overall workforce (13%).

U.S. Solar Workforce (USEER)

- At the end of 2022, almost 350,000 U.S. employees spent some of their time on solar, mostly in the construction sector.



- This is a growth of 3.7% (12,256) over 2021 and 9% growth over 2019, rebounding to pre-pandemic levels of solar employment.
  - The largest job growth came from the utilities industry (+4,041 new jobs) with the other categories gaining 1-2k jobs each.
- Women are underrepresented within the solar workforce (31%) compared to the national workforce average (47%).
- Approximately 11% of the workforce is represented by a union or collective bargaining agreement, compared to the national workforce average of 7%.
- The solar workforce was more racially diverse than the national workforce average (26% of non-white workers versus 23%). Hispanic or Latino workers were relatively overrepresented while Black or African American workers were relatively underrepresented, compared to the national average workforce.

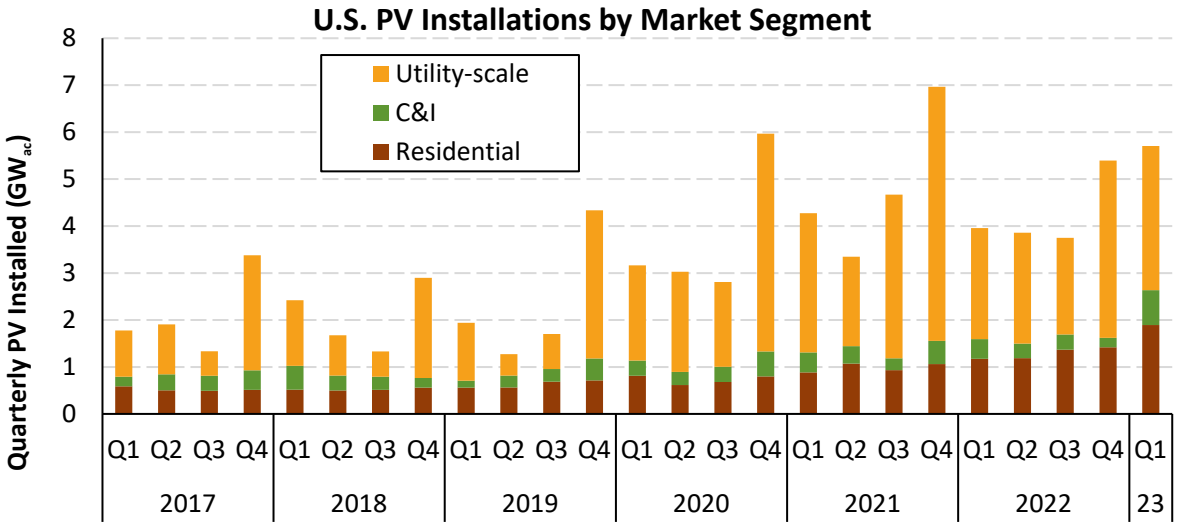
Source. DOE, U.S. Energy & Employment Jobs Report. July 2023.

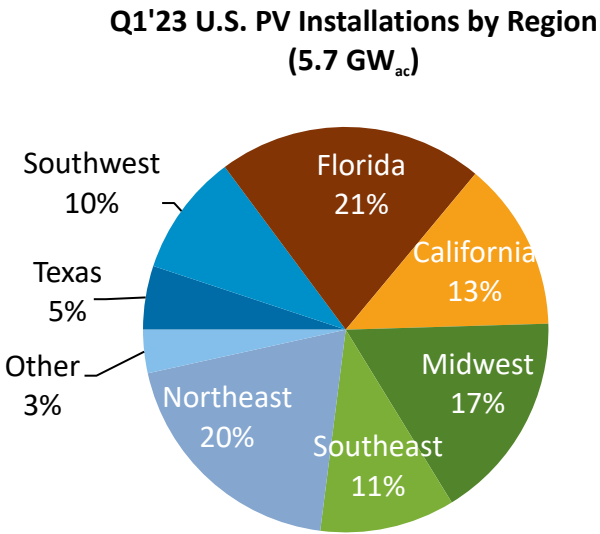
U.S. Installation Breakdown Annual: EIA (GW_{ac})

According to EIA data, the United States installed 5.7 GW_{ac} of PV in the first quarter of 2023—up 44%, y/y and 6% q/q (representing the first increase in PV deployment between Q4 and Q1).

– Residential (1.9 GW) and C&I (0.7 GW) had their biggest quarters ever, while utility-scale PV (3.1 GW) had its biggest Q1 ever.

In Q1 2023, Florida and California installed a combined 2 GW, or 35% of U.S. PV capacity.





Note: EIA reports values in W_{ac} which is standard for utilities. The solar industry has traditionally reported in W_{dc}. Installation growth in Q1 2023 in some states appears to be a result of EIA updating cumulative installation levels rather than installations during that period.

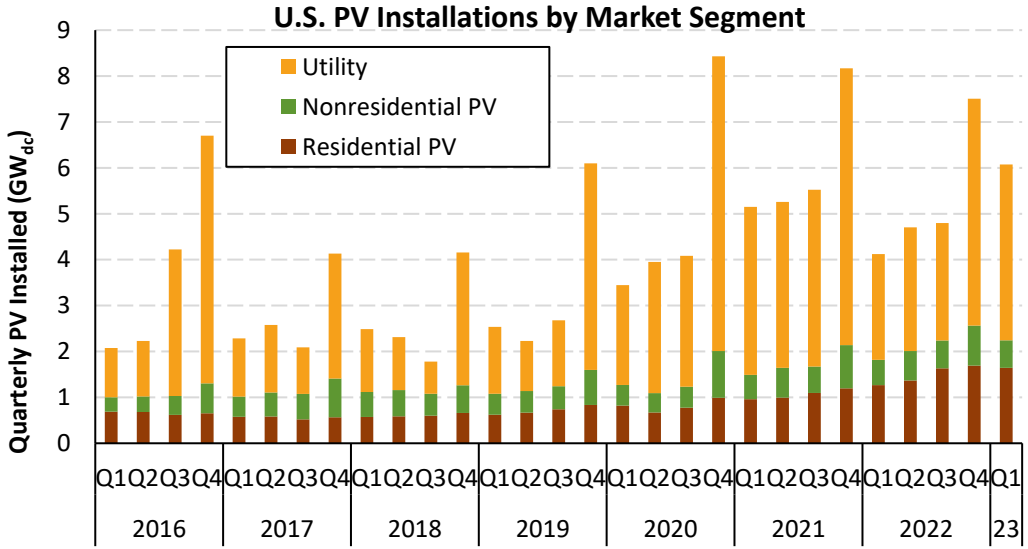
Sources: EIA, "Electric Power Monthly," forms EIA Form 023, EIA Form 826, and EIA Form 861 (November 2022, February 2021, and February 2019).

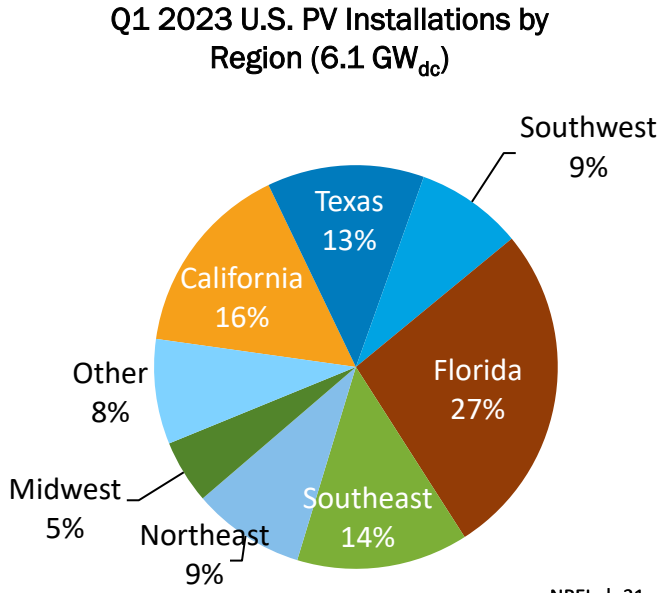
U.S. Installation Breakdown Annual: SEIA (GW_{dc})

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

According to SEIA data, the United States installed 6.1 GW_{dc} of PV in the first quarter of 2023—up 47% from the first quarter of 2022—and the largest Q1 on record.

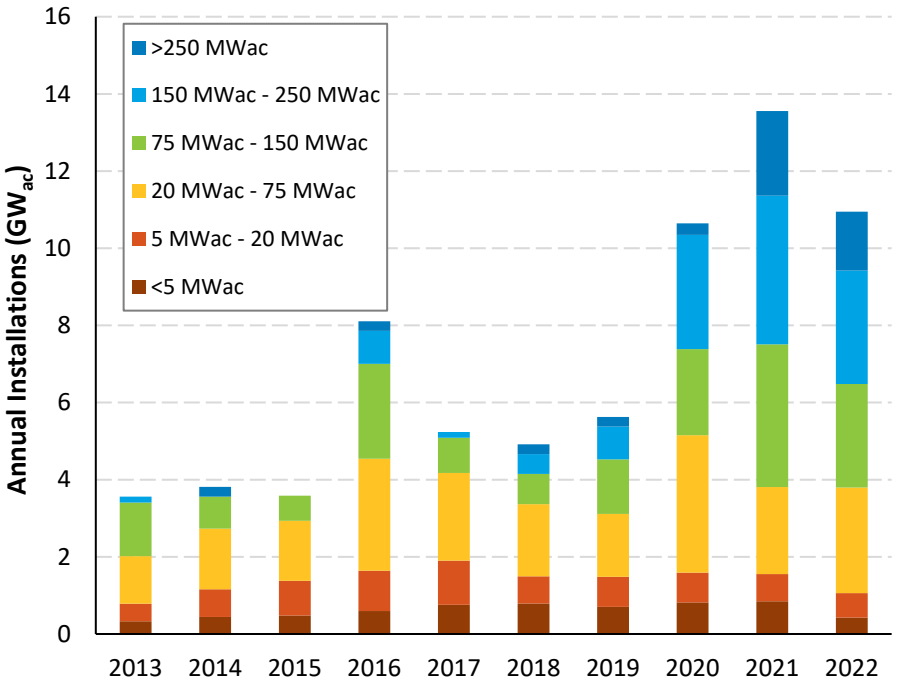
- Residential PV (1.6 GW_{dc}) had its second biggest quarter ever, up 30%, y/y, which would have been even higher but for heavy rains slowing some installations. Utility-scale PV (6.1 GW_{dc}) had its largest 1st quarter ever, aided by delayed projects coming on-line. C&I PV (0.6 GW_{dc}) was up 9% during this period, though Community Solar was down due to interconnection and siting challenges.
- SEIA reports that over half of U.S. PV capacity installed in Q1 2023 was in California, Texas, and Florida.





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

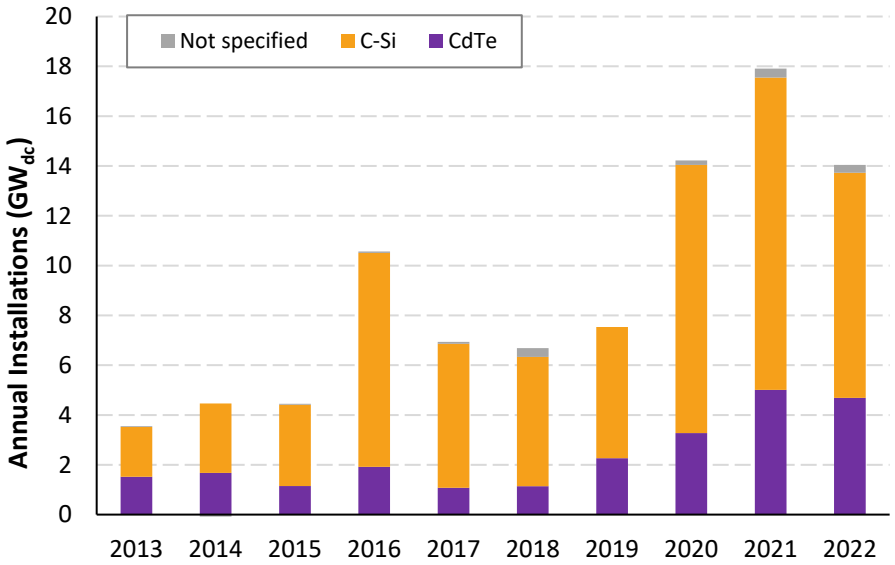
>1 MW_{ac} U.S. PV System Size Distribution by Year



- Over the past 10 years, the growth in annual deployment of utility-scale PV has mostly come from systems greater than 20 MW_{ac}, with the largest growth coming from those greater than 150 MW_{ac}.
- Only 4% of the U.S. PV systems (greater than 1 MWac installed) installed in 2013 were above 150 MW_{ac}, compared to 41% of 2022 installations.

Note: Data is from an "early release" and is not final.
Source: U.S. EIA, Form EIA-860 2022ER.

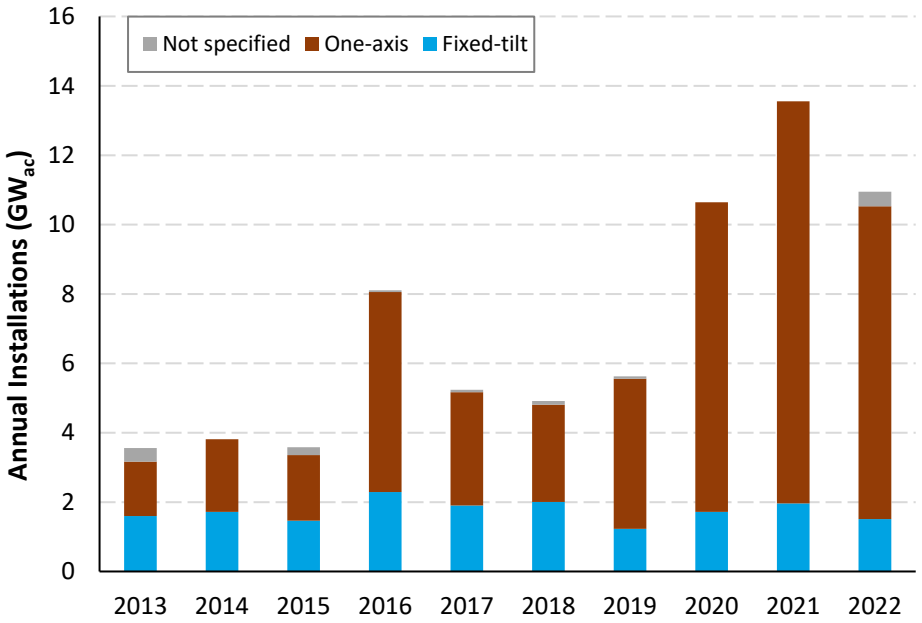
>1 MW_{dc} U.S. PV Technology Distribution by Year



- Though thin-film PV represented around 4% of global PV deployed from 2013 through 2022, it accounted for 27% of U.S. utility-scale PV deployments during this period.
  - 34% of U.S. utility-scale PV and ~21% of all U.S. PV systems built in 2022 used CdTe panels.

Note: Data is from an "early release" and is not final. "Not specified" also includes a small number of CIGS and a-Si modules.
Source: U.S. EIA, Form EIA-860 2022ER.

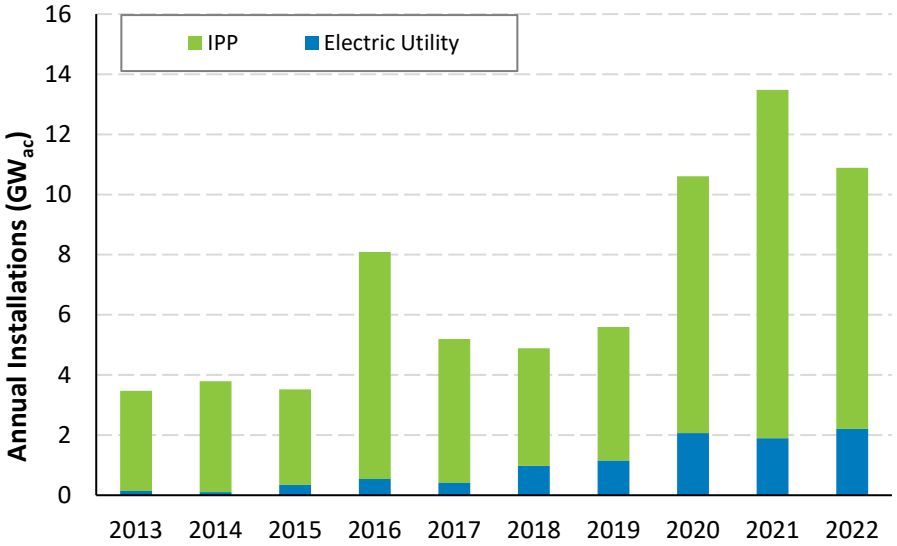
>1 MW_{ac} U.S. PV Mounting Type by Year



- The use of single-axis/one-axis tracking in the U.S. utility PV market has grown significantly over the past decade.
  - At the end of 2022, 73% of all U.S. utility-scale PV systems used single-axis tracking. And 86% of U.S. utility-scale PV systems installed in 2022 used single-axis tracking.
  - This growth can be attributed to the reduced cost and increased reliability of trackers, making them the economic choice in a broader distribution of PV systems (e.g., less irradiant climates).

Note: Data is from an "early release" and is not final. "Not specified" may also include a small number of two-axis tracking systems.
Source: U.S. EIA, Form EIA-860 2022ER.

>1 MW_{ac} U.S. PV Asset Ownership by Year



- Most U.S. utility-scale PV systems—80% of installations in 2022, 86% cumulative—are owned by independent power producers, which sell their electricity under long-term contracts.
- However, from 2013 to 2022, 9.8 GW_{ac} of PV installed was owned by electric utilities—2.2 GW_{ac} was installed in 2022 alone.
- Since 2016, utilities in Florida and Virginia have owned 72% of utility-owned installations (the Florida Public Service Commission (PSC) and Virginia General Assembly established rules that encourage direct utility ownership of solar assets); however, this percentage has fallen the past two years (dropping to 64% in 2022 from 85% in 2020) as more utility-owned assets are built in other states.

Note: Data is from an "early release" and is not final.
Source: U.S. EIA, Form EIA-860 2022ER.

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

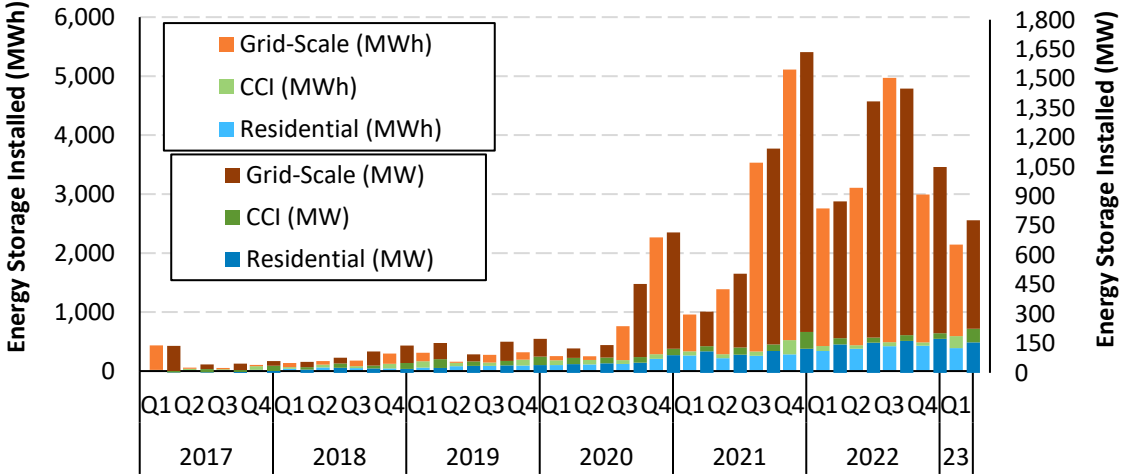
The United States installed approximately 2.1 GWh (0.8 GW_{ac}) of energy storage onto the electric grid in Q1 2023, -22% (-11%) y/y as a result of 1.8 GW of grid-scale projects pushed to later in the year.

- While residential storage had its highest Q1 on record, it had a q/q decline for the first time in nearly two years.
- Community, Commercial, & Industrial (CCI) had its second highest quarter on record, likely due to delayed Q4 projects coming online.

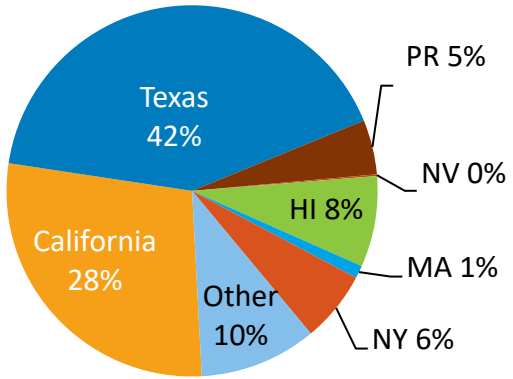
Texas led the grid-scale market, followed by California; New York led CCI, followed by California; and California led the residential sector followed by Puerto Rico.

- Because of the high concentration of the market in California and Texas, delays in California, due to interconnection queue challenges, led to an overall decline in the market.
- Maryland became the 10th state to establish a goal for energy storage procurement, voting in April to add 750 MW of battery storage by 2027, an additional 750 MW through 2030 and a further 1.5 GW through 2033.

U.S. Energy Storage Installations by Market Segment



Q1 2023 U.S. Energy Storage Installations by Region (2.1 GWh)



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

Source: Wood Mackenzie Power & Renewables and Energy Storage Association, U.S. Energy Storage Monitor: Q2 20223.

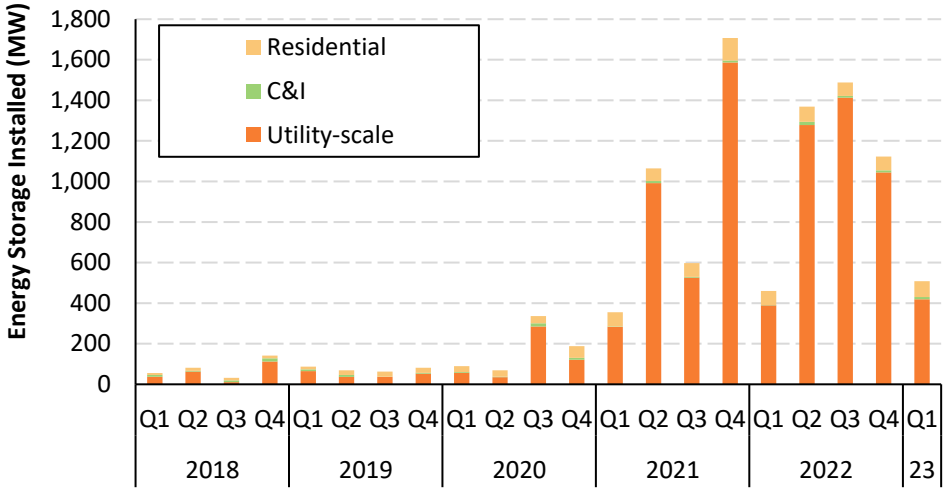
U.S. Energy Storage Installations by Market Segment (EIA)

EIA reports that the United States installed approximately 0.5 GW_{ac} of energy storage onto the electric grid in the first 3 months of 2023— up 6% y/y as a result of high levels of utility-scale and residential deployment.

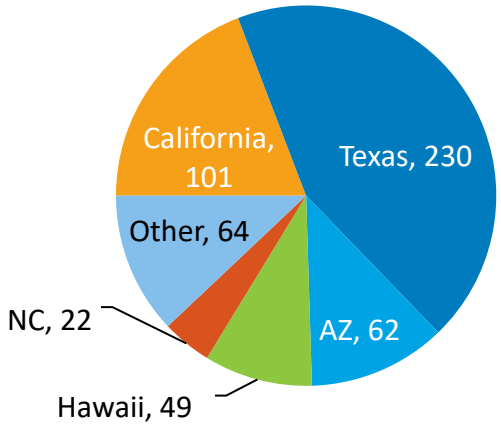
Texas represented approximately 44% of installed battery storage capacity, followed by California (22%).

– The top five markets represented 88% of installed energy storage capacity.

U.S. Energy Storage Installations by Market Segment

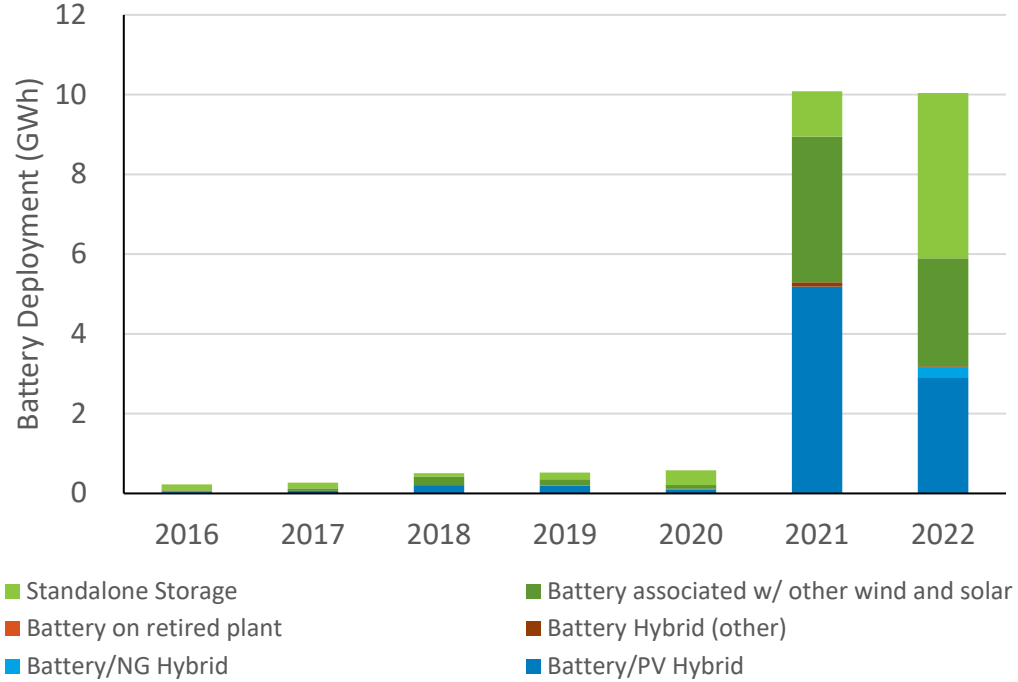


Q1 2023 U.S. Energy Storage Installations by Region (500 MW)



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

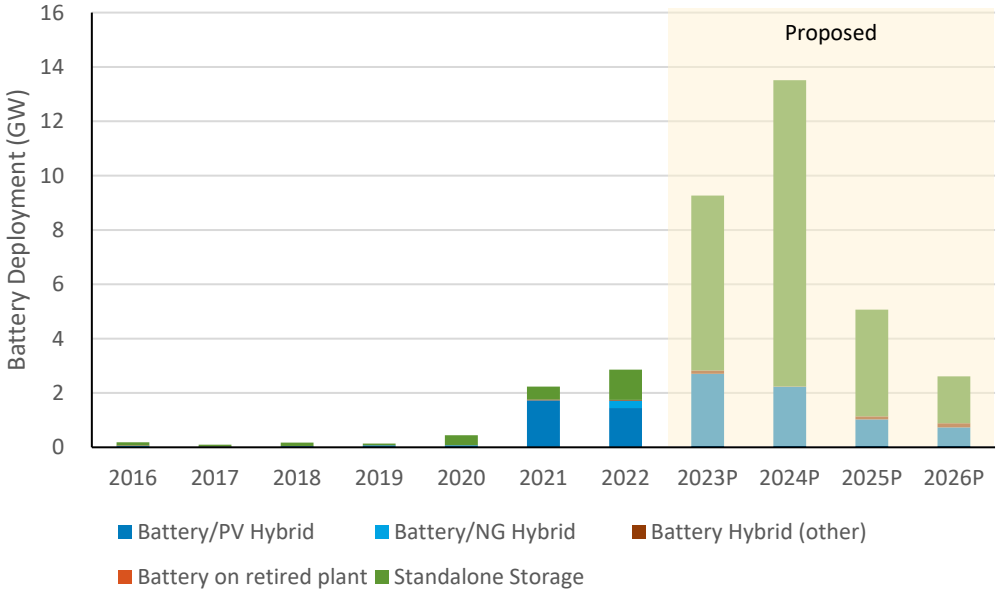
U.S. Utility-Scale PV and Batteries



- EIA has initially reported 10 GWh (4.1 GW) of utility-scale battery storage installed in 2022 – flat, y/y, in GWh but a 0.7 GW increase from 2021.
  - The past two years are considerably higher than any previous year.
- 89% of GWh of utility-scale battery storage installed in 2021 was co-located with an electric generation asset (or retired plant), however in 2022 that number dropped to 59%.
  - Several of these standalone facilities have capacity storage agreements with utilities to manage renewable energy integration and grid optimization in California and Texas.
- In 2022, PV+battery facilities represented 29% of battery storage capacity (and 7% of PV capacity), compared to 51% of battery capacity (and 3% of PV capacity) in 2021).
  - Percentages only include facilities with both technologies; not co-located, distinct facilities.

Note: hybrid plants report the same plant code as energy generation technologies. Battery plants associated with other wind and solar have no listed associated plant but have been designated as handling excess wind and solar capacity.
Source: U.S. EIA, Form EIA-860 2022ER.

U.S. Utility-Scale PV and Batteries



- Despite record levels of battery storage deployment, proposed plants tracked by EIA show a 2-4X growth in annual deployment over the next two years.
- Many battery plants are listed as hybrid with other electric generation technologies, though the majority are listed as standalone systems (though may still be associated with renewable energy assets).

Note: hybrid plants report the same plant code as energy generation technologies. Battery plants associated with other wind and solar have no listed associated plant but have been designated as handling excess wind and solar capacity.
Source: U.S. EIA, Form EIA-860 2022ER.

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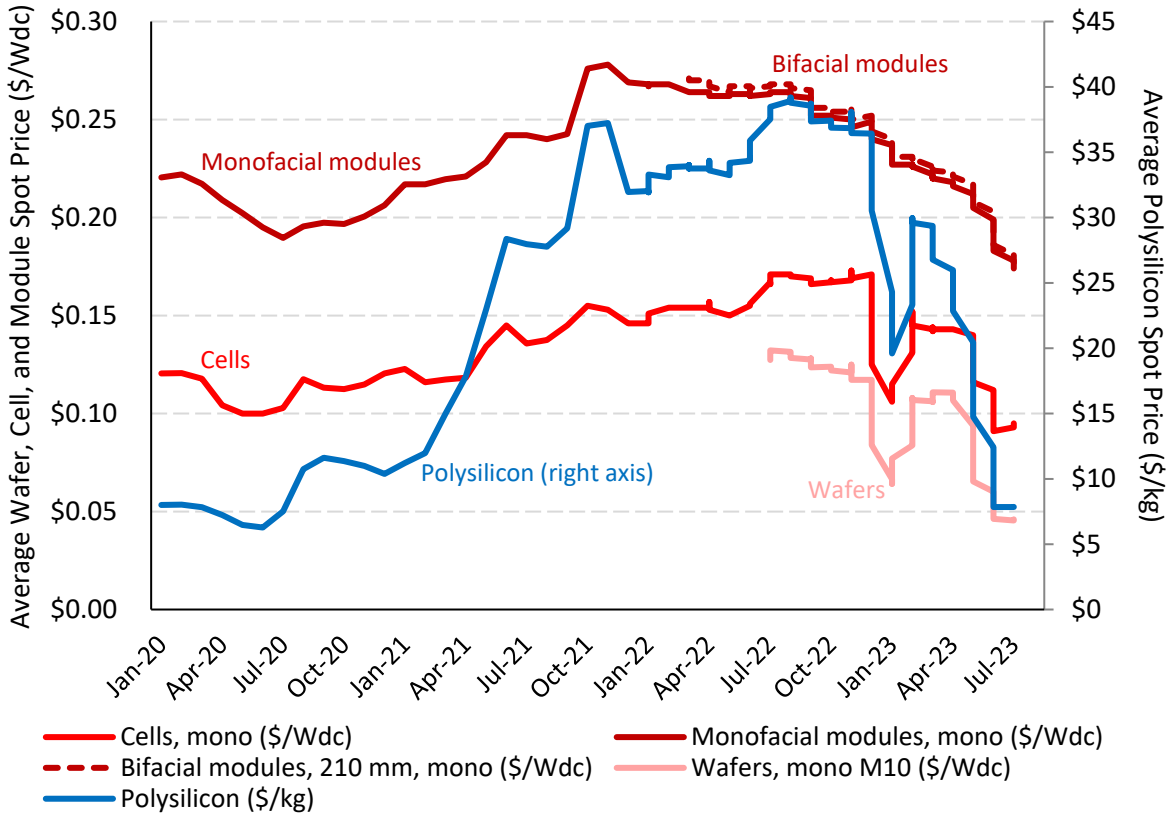
- **Global polysilicon spot prices dropped about 70% from mid-April to mid-July, reaching the $8/kg level for the first time in 3 years.**
- **Global module prices reached their lowest ever point at $0.17/W because of oversupply, competition, decreasing module commodity (e.g., silver, aluminum) and freight prices, and a decline in the value of the yuan vs. the dollar—despite continued strong demand for modules worldwide.**
- **In Q2 2023 (first 2 months), the average U.S. module price ($0.37/$W_{dc}$) was up 2% q/q with no change y/y and modules trading at a 76% premium over the global spot price for monofacial monocrystalline silicon modules.**
- **LevelTen reports that after several years of rising prices, solar PPA prices in the U.S. showed signs of stabilization in Q2.**
- **From H1 2022 to H1 2023, distributed PV system prices generally increased in nominal dollars but were down when accounting for inflation.**

PV Value Chain Global Spot Pricing



Source: BloombergNEF, Solar Spot Price Index (7/13/23); BloombergNEF, Bimonthly PV Index (7/6/23).

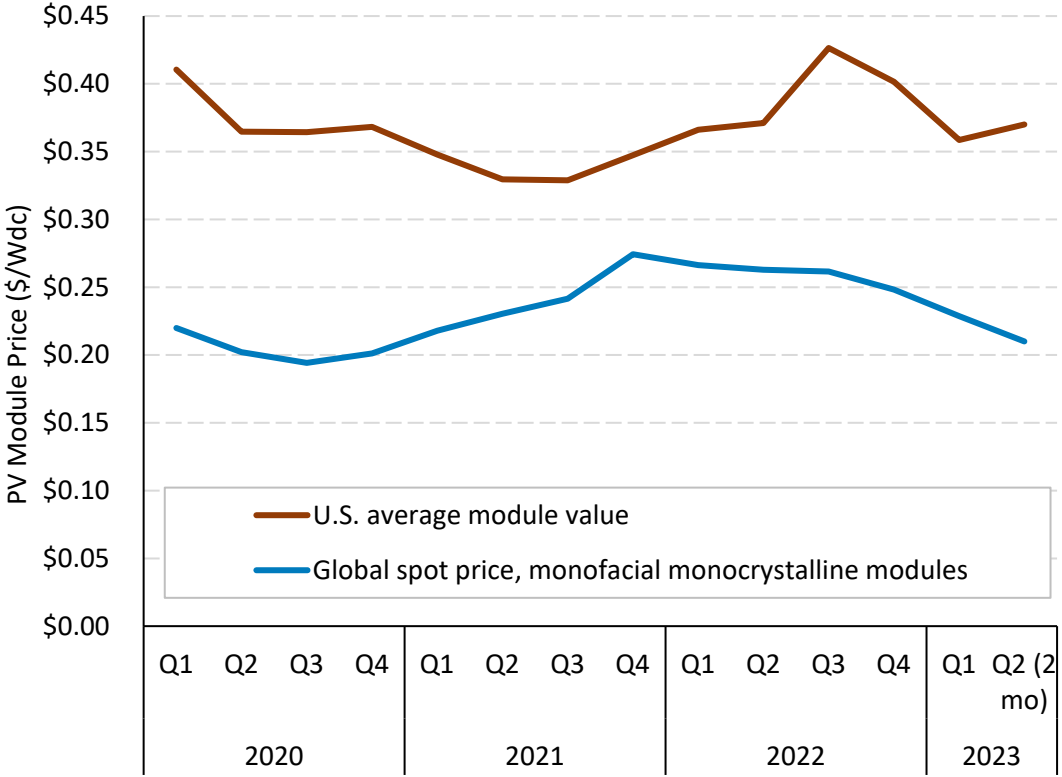
Global polysilicon spot prices dropped about 70% from mid-April to mid-July, reaching the $8/kg level for the first time in 3 years.

- Oversupply continues to increase, with BNEF reporting June's polysilicon production equivalent to 46 GW_{dc} of module production, or about 1.7x projected 2023 global module demand on an annualized basis.
- The polysilicon price dropped below the weighted average cost of producing polysilicon, but capacity expansions continue.

Global prices also decreased substantially for wafers (60%) and cells (30%) during this period.

Global module prices reached their lowest ever point at $0.17/W because of oversupply, competition, decreasing module commodity (e.g., silver, aluminum) and freight prices, and a decline in the value of the yuan vs. the dollar—despite continued strong demand for modules worldwide.

Module Prices: Global Versus United States



In Q2 2023 (first 2 months), the average U.S. module price ($0.37/$W_{dc}$) was up 2% q/q with no change y/y and modules trading at a 76% premium over the global spot price for monofacial monocrystalline silicon modules.

The directional trend in U.S. module prices deviated from the trend in global module prices, creating the biggest gap between the two prices since Q4 2020.

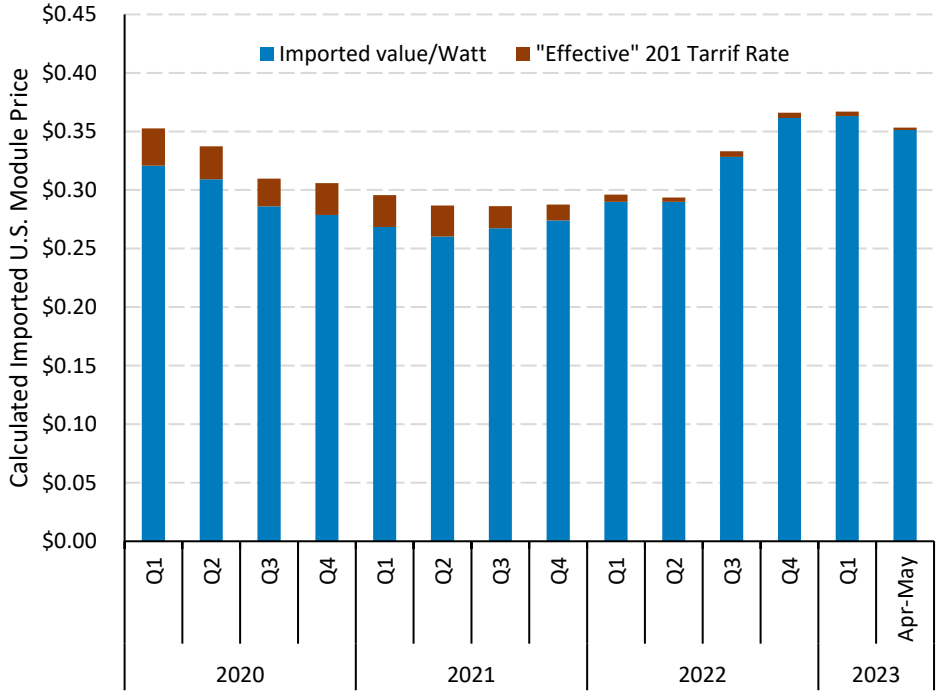
- U.S. Customs and Border Protection (CBP) continues to detain module imports under the Uyghur Forced Labor Prevention Act (UFLPA), which was implemented June 21, 2022.
- Although CBP has released some shipments, analysts believe the supply constraints caused by the detainments along with high demand for modules contributed to the U.S. module price in Q2 2023.

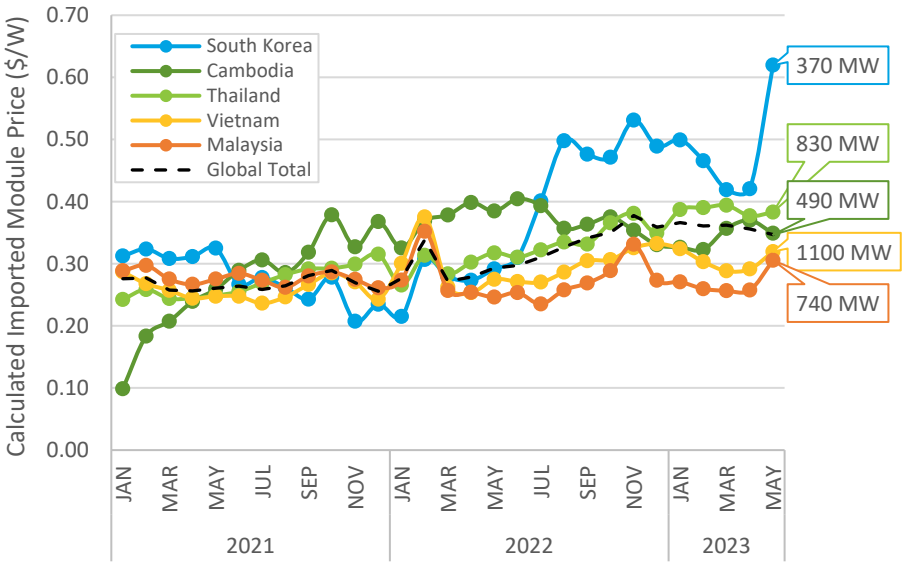
Source: BloombergNEF, Solar Spot Price Index (7/13/23); BloombergNEF, Bimonthly PV Index (7/6/23); EIA, Monthly Solar Photovoltaic Module Shipments Report (7/17/23); Wood Mackenzie & SEIA, US Solar Market Insight: Q2 2023 (6/23).

Calculated Imported U.S. Module Pricing (c-Si and CdTe)

Based on the reported value and capacity of imported PV modules, the average price of a PV module in the United States appeared to be cooling its upwards climb in Q1 2023 at $0.36/W before tariffs.

– Prices remain highly sensitive to the country of import, with modules from Vietnam and Malaysia fetching the lowest prices.

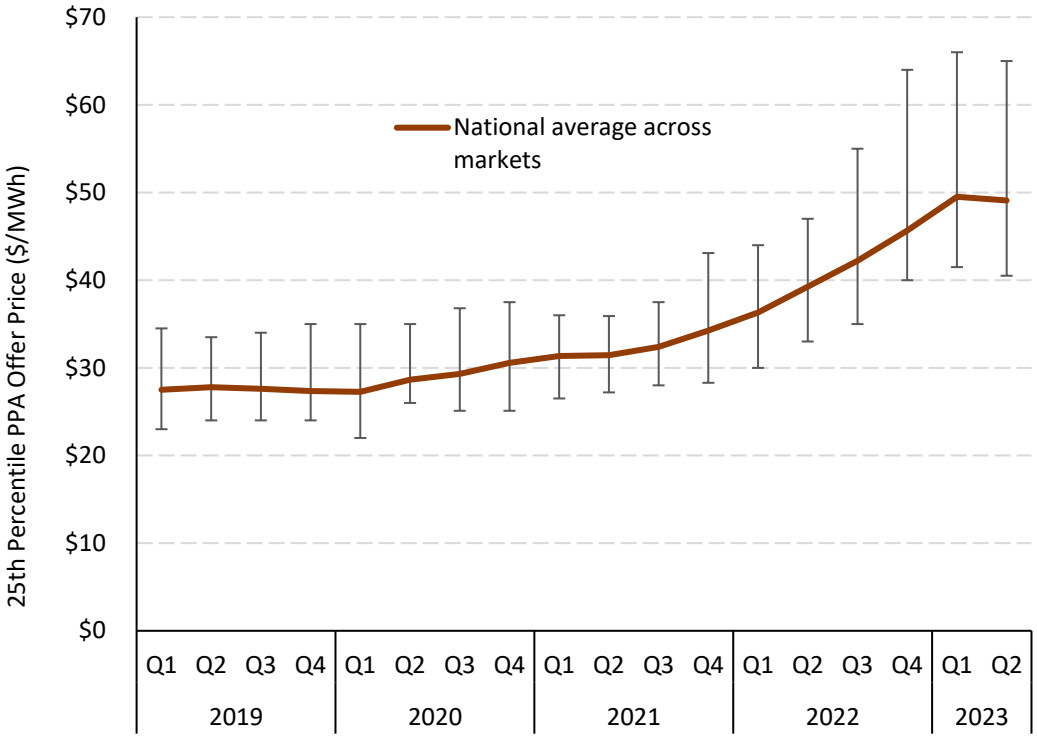




Note: The tariff rate was adjusted by the capacity subject to the tariffs. Manual corrections were made due to suspected data entry errors for HTS code 8541430010/80: Cambodia (February 2022), Malaysia (June 2020), Vietnam (July 2019), and India (July 2022-present).

Sources: Imports by HTS code: 8541460015(2018-2021)/8541430010(2022-) for c-Si and 8541460035(2018-2021)/8541430080(2022-) for thin film, 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 7/25/23.

U.S. Solar PPA Pricing (LevelTen)

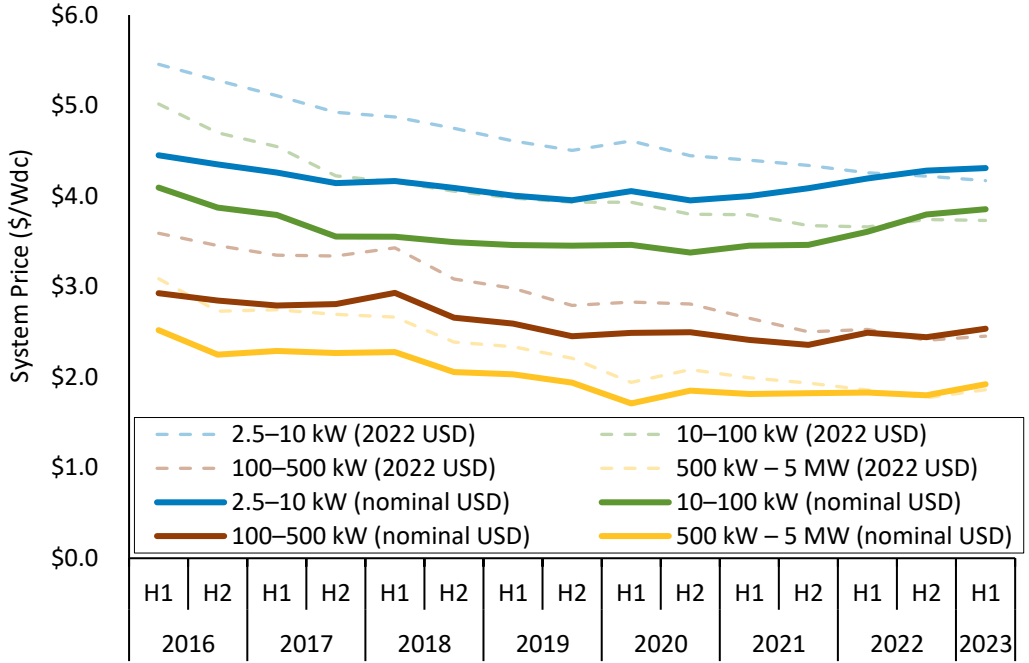


- LevelTen reports that after several years of rising prices, solar PPA prices in the U.S. showed signs of stabilization in Q2.
  - LevelTen attributes this change to: 1) Treasury guidance which has provided more clarity on the rules of the new tax credits within the Inflation Reduction Act; and 2) improved supply chain conditions.
  - One exception to PPA price stability was in Texas, where state legislatures have introduced legislation that would harm renewable energy development, as well as the increase in basis risk in West Texas.
- In Q2 2023, U.S. Solar PPA prices dropped 1%, q/q, but were still up 25%, y/y.
  - Offered wind PPA's increased 13%, q/q, and 30%, y/y.

Note: "basis risk" refers to the risk a project owner takes by purchasing a hedge on electricity price at an electricity hub, while selling the electricity from a project into the spot market at a node.

Source: LevelTen, PPA Price Index.

Distributed PV System Pricing From Select States



2023 MW reported YTD: Arizona (113), California (521), Massachusetts (45), New York (335)
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. Dataset excludes PV+battery hybrid systems.
Sources: Arizona Goes Solar (7/6/23); California Distributed Generation (5/31/23); Massachusetts Lists of Qualified Generation Units (7/7/23); Solar Electric Programs Reported by NYSERDA (7/4/23).

From H1 2022 to H1 2023, the median reported distributed PV system price—**in nominal U.S. dollars (USD)**—across Arizona, California, Massachusetts, and New York:

- Increased 3% to $4.31/Wdc for systems 2.5 to 10 kW
- Increased 7% to $3.85/Wdc for systems 10 to 100 kW
- Increased 2% to $2.53/Wdc for systems 100 to 500 kW
- Increased 5% to $1.92/Wdc for systems 500 kW to 5 MW.

From H1 2022 to H1 2023, the median reported distributed PV system price—**in 2022 (inflation-adjusted) dollars**—across these states:

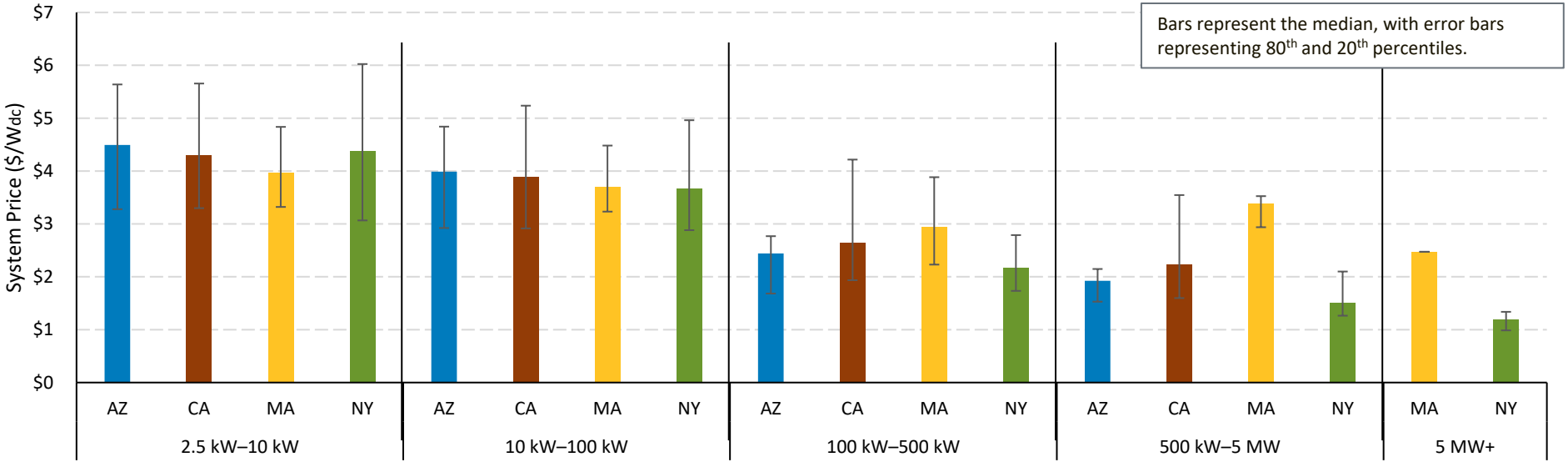
- Decreased 2% for systems 2.5 to 10 kW
- Increased 2% for systems 10 to 100 kW
- Decreased 3% for systems 100 to 500 kW
- Remained the same for systems 500 kW to 5 MW.

Adjusting for inflation reveals the continuing real distributed PV cost reductions over the past several years of economic volatility.

Distributed System Pricing From Select States, H1 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 2.5–10 kW, nominal price increases varied between H1 2022 and H1 2023:
  - 4% in Arizona, 2% in California, 4% in Massachusetts, 14% in New York.
- Large system prices are based on relatively few systems.
  - For example, Massachusetts only installed three systems of 500 kW – 5 MW and one system larger than 5 MW in H1 2023.



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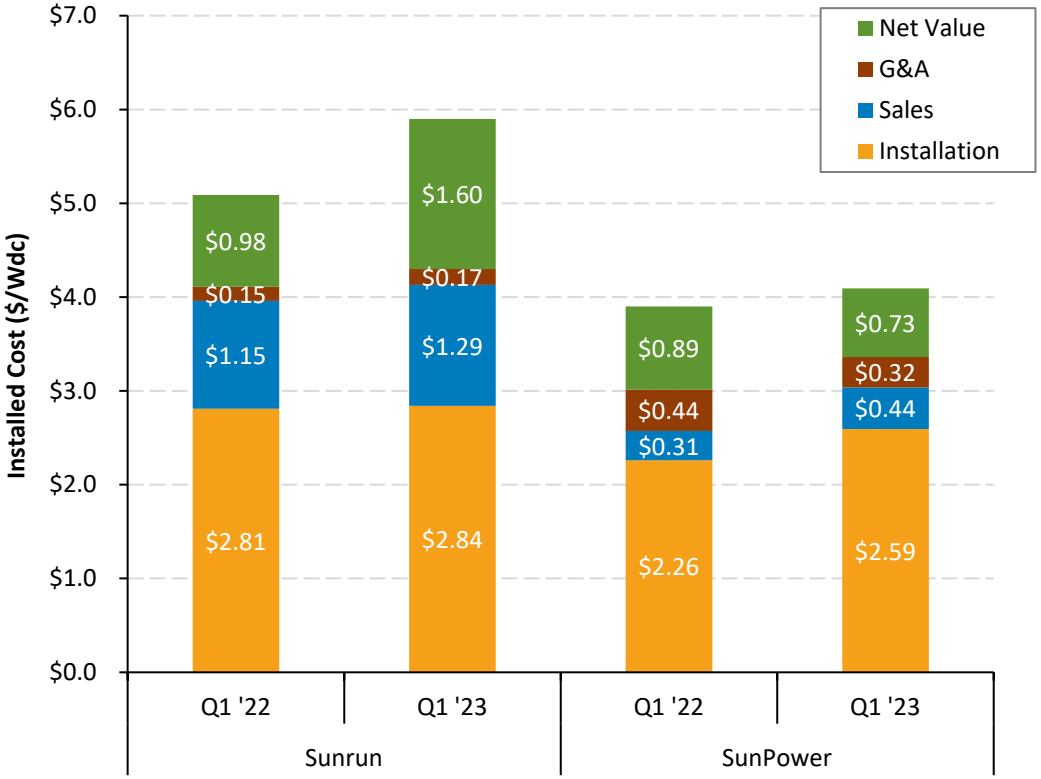
Sunrun and SunPower Cost and Value, Q1 2023



Large residential installers reported continued strong demand for PV in Q1 2023 along with rising prices caused in part by inflation and higher interest rates.

- New customer additions increased 20%–97% in Q1 2023 vs. Q1 2022 for Sunrun, Sunnova, and SunPower.
- Demand drivers included the high cost of retail electricity, electric vehicle purchases, creation of virtual power plants, PV on new homes, permitting with SolarAPP+, and Inflation Reduction Act incentives.
- California's April 2023 net-metering change boosted Q1 2023 demand and created backlogs.

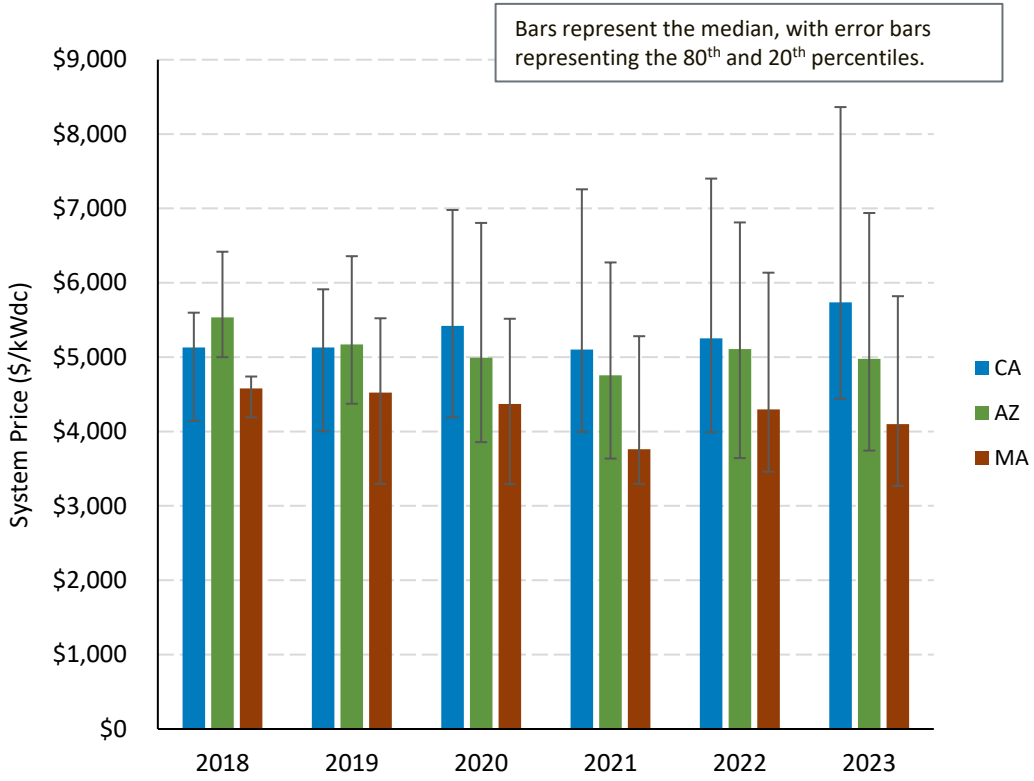
Prices include PV systems increasingly paired with batteries.

- Q1 2023 attachment rates were 15%–20%.
- SunPower's California attachment rate was greater than 20% in April owing to the state's policy change.

Installers reported ample PV and storage equipment supply and decreasing equipment costs.

Sources: Corporate filings.

Residential U.S. PV+Storage Pricing



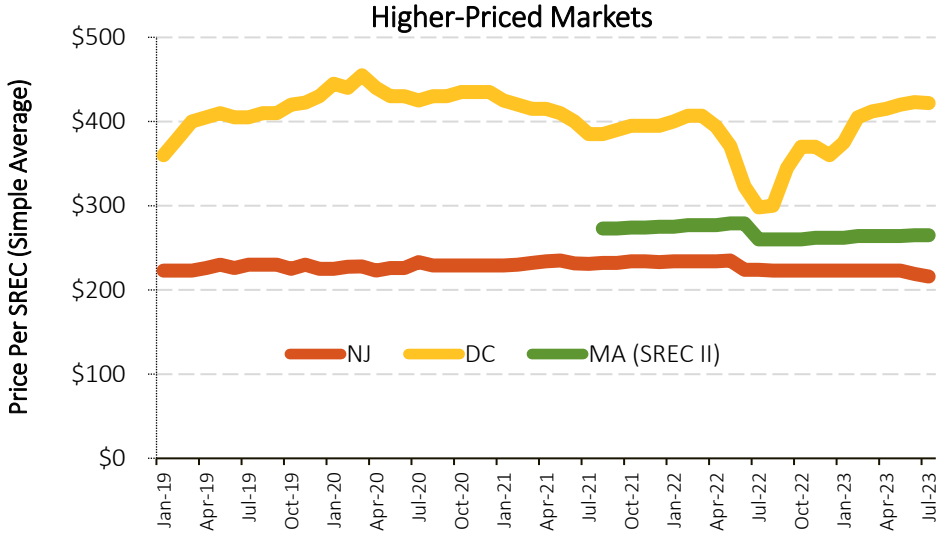
- In the first several months of 2023, residential PV+storage system prices in Arizona, California, and Massachusetts varied between states and internally.
  - Prices may vary due to differences in storage power and capacity, permitting and interconnection differences, local competitive factors, and installer experience.
- Compared with full median 2022 values, prices (in dollars per kW_{dc} of PV capacity) increased in the first several months of 2023 in California (9%) while decreasing in Massachusetts (5%) and Arizona (3%).

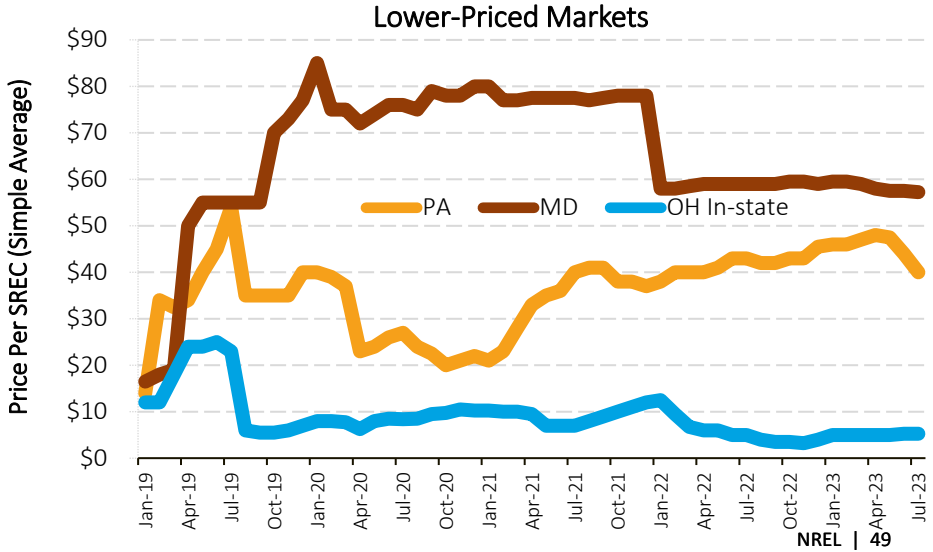
2023 YTD residential PV+storage sample, after data cleaning (MWdc): Arizona (8), California (24), Massachusetts (5)
Sources: Arizona Goes Solar (7/6/23); California Distributed Generation (5/31/23); Massachusetts Lists of Qualified Generation Units (7/7/23).

SREC Pricing

- Most Solar Renewable Energy Credit (SREC) prices stayed relatively flat during this period.
- Active SREC programs have closed in New Jersey, Massachusetts, and Ohio.

- In July 2022, DC Council introduced a law that would increase the Solar RPS from 10% to 15% and increase the associated ACP over the next ten years. The DC SREC market soon recovered. The RPS was codified and went into effect in March 2023.
  - SRECTrade reported that the DC SREC market had experienced unstable conditions due to oversupply and lack of liquidity over the previous two years.
- In 2021, Pennsylvania introduced legislation that would increase its solar carve-out, causing SREC prices to increase. However, the legislation has yet to pass.





Source: SRECTrade, https://www.srectrade.com/, accessed 7/18/23.

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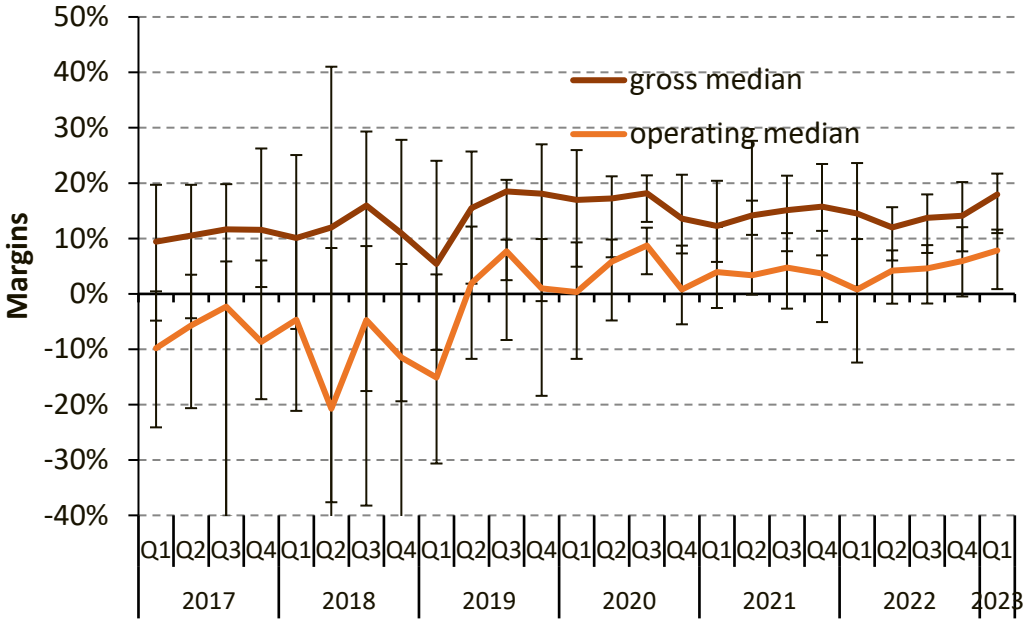
- **In Q1 2023, margins for most PV companies increased as demand increased, aided by a significant drop in polysilicon prices.**
  - Available data for 8 of the leading PV module suppliers found that Q1 2023 shipments were 61% higher than shipments from these companies in Q1 2022.
- **Since the IRA's passage, over 185 GW of U.S. manufacturing capacity has been announced across the solar supply chain, including 44 separate new manufacturing plants and 6 expansions.**
- **The Invesco Solar ETF fell 8% in Q2 2023, in contrast to the S&P 500 (up 8%) and Russell 2000 (up 5%), continuing a generally downward trend that started in August 2022.**

PV Manufacturers' Margins



- PV manufacturers, mostly Chinese companies, have generally been profitable since 2019.
- In Q1 2023, margins for most PV companies increased as demand increased, aided by a significant drop in polysilicon prices.

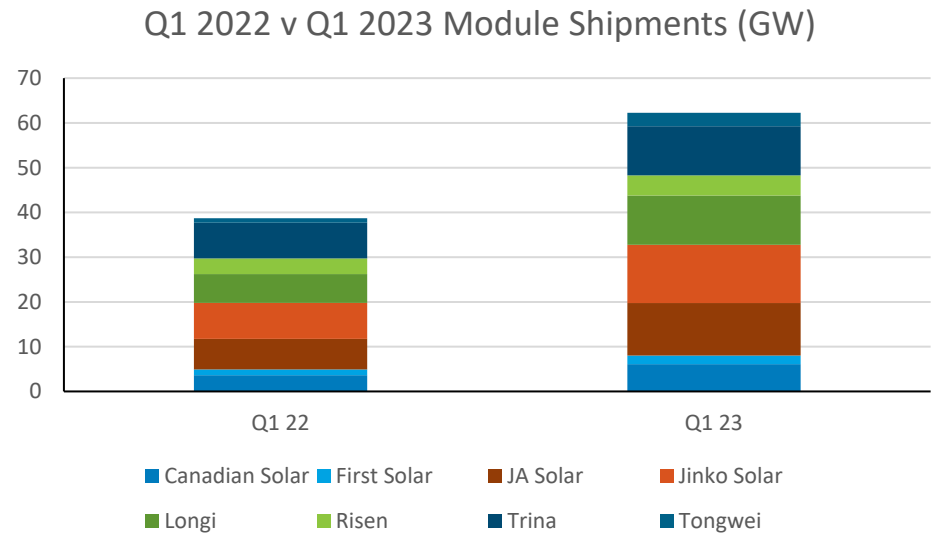
Lines represent the median, with error bars representing 80th and 20th percentiles for the following companies in Q1 2023: Canadian Solar, First Solar, JA Solar, Jinko Solar, LONGi, Maxeon, Motech Industries, REC Silicon, Renesola, Risen, Shanghai Aiko, Shanghai Aerospace, Tongwei, Trina Solar, and United Renewable Energy. Margin data from Hanwha Q Cells, Sunpower, and Yingli are also included from Q1 2017 to Q1 2023 where available.

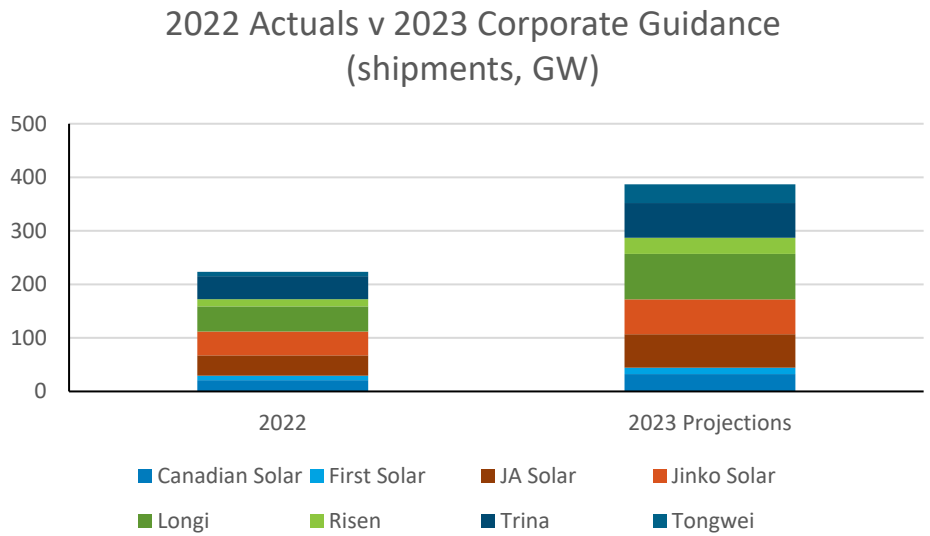
Note: Gross margin = revenue – cost of goods sold (i.e., the money a company retains after incurring the direct costs associated with producing the goods or services it sells); operating margin = gross margin minus overhead and operating expenses (i.e., the money a company retains before taxes and financing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

Sources: Company figures based on public filings and finance.yahoo.com.

PV Manufacturers' Margins

- Available data for 8 of the leading PV module suppliers found that Q1 2023 shipments were 61% higher than shipments from these companies in Q1 2022.
- Corporate guidance from these companies in Q1 2023 show an expectation that 2023 shipments will increase 71%, y/y.



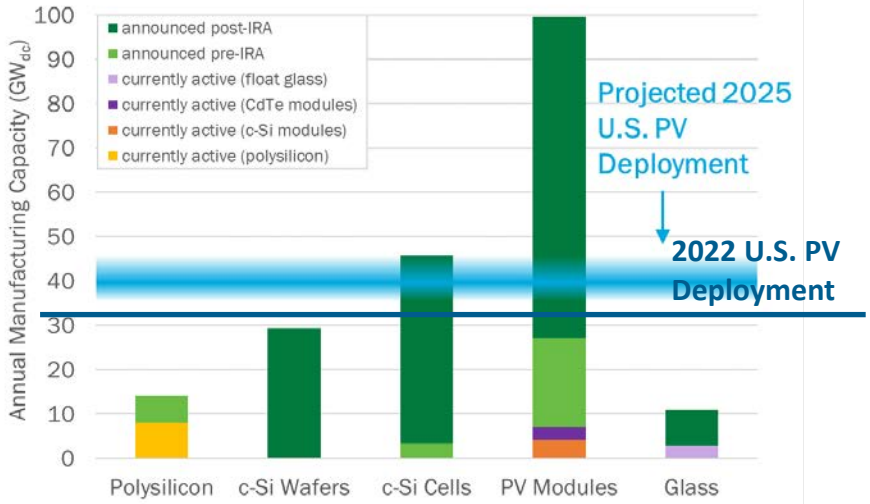


Sources: Company figures based on public filings and finance.yahoo.com; African Business (05/31/23), EQ International (06/10/23), LONGI (05/24/23), PVTech (05/16/23), Solarbeglobal (05/06/22),Taiyang News (03/27/23, 04/24/23, 07/19/22).

Domestic Manufacturing Announcements

Since the IRA's passage, over 185 GW of U.S. manufacturing capacity has been announced across the solar supply chain, from 44 separate new manufacturing plants and 6 expansions. These include:

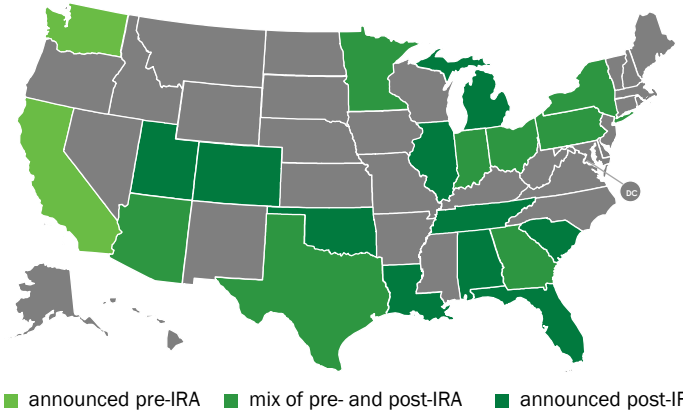
- 93 GW of solar module capacity (including 13 GW of thin film)
- 46 GW of c-Si cell capacity
- 29 GW of c-Si wafer capacity
- 17 GW of BOS (including inverters, trackers, backsheets, etc.).*



A wide variety of announcements have been made in Q2 2023, covering wafers, cells, modules, trackers, junction boxes, and even PV recycling, with the announced capacity for wafers and cells exceeding 2022 deployment levels for the first time.

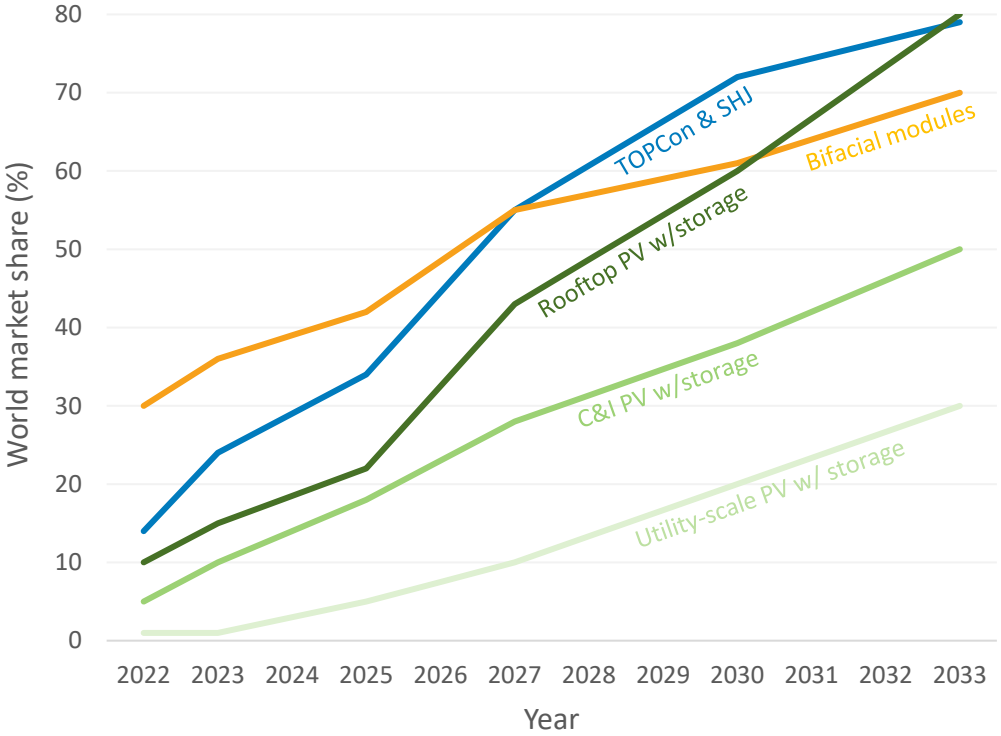
- Notable announcements of the last several months include:
  - 4-GW vertical wafer/cell/module plans from VSK
  - Both HJT and TOPCon c-Si cell plans from Solar4America
  - 20-GW cell/module facility from Revkor/H2 Gemini in UT
  - 5 GW of ingot/wafer from Norsun
  - 2 GW of cells from Meyer Burger in CO
  - 3.5 GW of CdTe modules from First Solar.

These announcements represent potential investment in at least 20 states.



Sources: Compilation of public announcements (see Appendix). *In addition to new PV module, c-Si cell, and wafer manufacturing, there is also 12 GW of tracker, 8 GW of encapsulant, 1 GW of manufacturing tools, and 10 GW of inverter manufacturing not graphed. Projections based on WoodMackenzie/SEIA and BNEF values.

Global PV Technology Projections Through 2033



The Intl. Technology Roadmap for Photovoltaic (ITRPV) projects global PV technology changes.

- Reports medians from industry surveys
- Covers crystallization, wafers, cells, modules, systems, and manufacturing.

Select world market shares are shown here.

- TOPCon and SHJ (n-type, more efficient) cells: 24% in 2022, 79% in 2033
- Bifacial modules: 30% in 2022, 70% in 2033 (mainly for utility-scale systems)
- Rooftop PV systems with storage: 10% in 2022, 80% in 2033
- Commercial and industrial (C&I) PV systems with storage: 5% in 2022, 50% in 2033
- Utility-scale PV systems with storage: 1% in 2022, 30% in 2033.

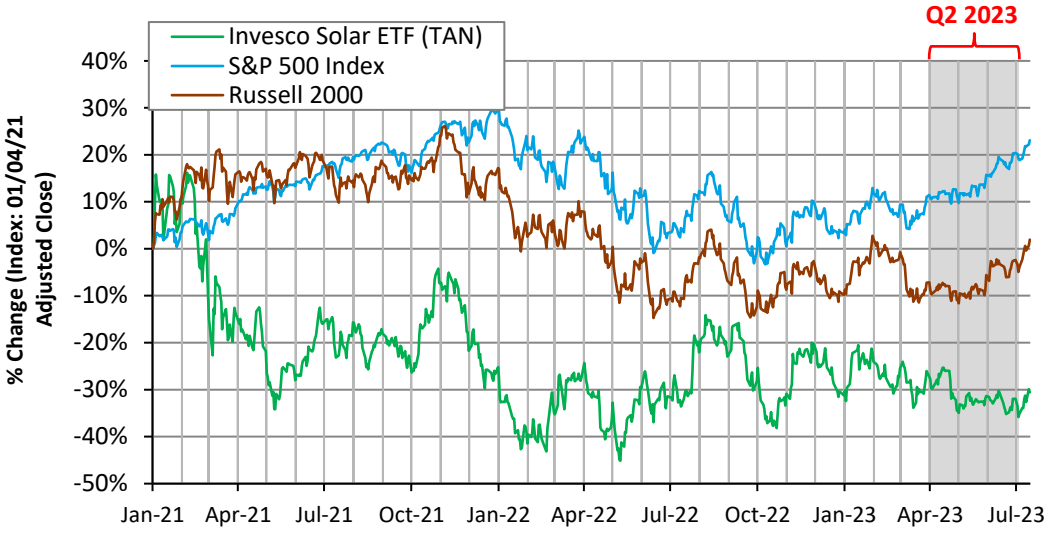
Module efficiencies rise between 2022 and 2033.

- p-type PERC modules rise from 21% to 23%.
- TOPCon and SHJ modules rise from 22% to 24%.
- Modules with tandem cells enter the market after 2025 and reach 4% market share in 2033, at which time they are 27% efficient.

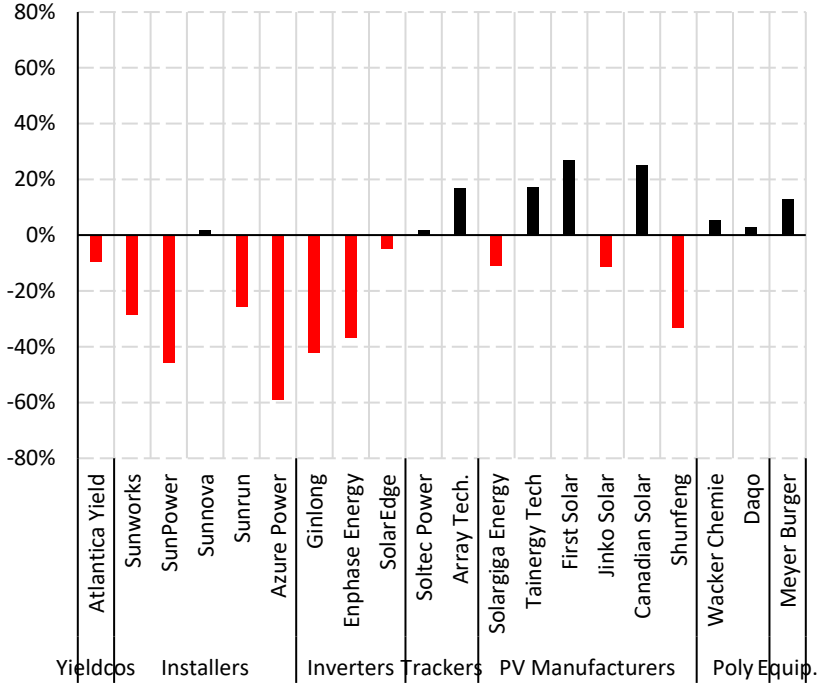
Source: VDMA, International Technology Roadmap for Photovoltaic (ITRPV): 2022 Results, April 2023.

Stock Market Activity

The Invesco Solar ETF fell 8% in Q2 2023, in contrast to the S&P 500 (up 8%) and Russell 2000 (up 5%), continuing a generally downward trend that started in August 2022. Despite high demand for modules, stocks across the module supply chain have been depressed by declining prices, smaller margins, worries about overcapacity, and investments shifting toward new sectors such as artificial intelligence. Rising interest rates, constraints on U.S. module imports, and the impact of California's new net-metering policy on residential installations have pulled down solar stock prices more broadly.



Individual Stock Performance (Q1 & Q2 2023)



Note: The TAN index is weighted toward particular countries and sectors. As of 7/18/23, 54% of its funds were in U.S. companies and 19% were in Chinese companies. Its top 10 holdings, representing 61% of its value, were Enphase, First Solar, SolarEdge, Sunrun, Xinyi, Shoals, GCL, Hannon Armstrong, Array Technologies, and Sunnova.

Sources: Invesco (7/19/23); Bloomberg News (6/20/23); PV Magazine (4/23, 5/23, 6/23).

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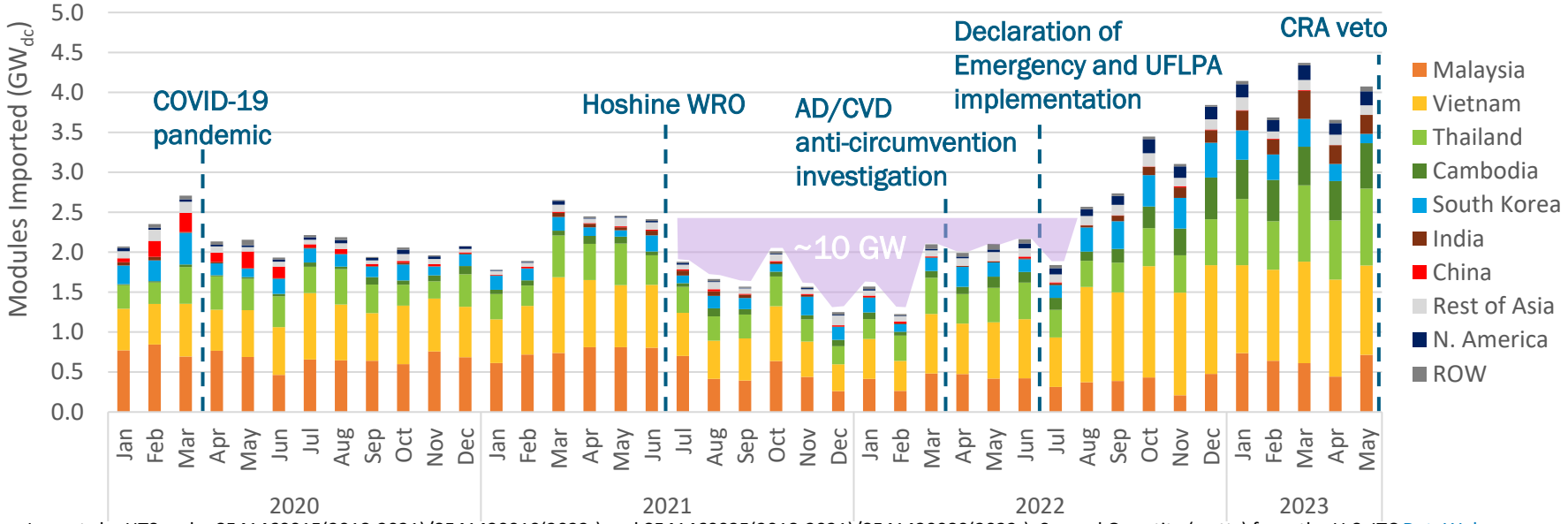
- **12.2 GW_{dc} of PV modules were imported into the United States in Q1 2023, +17% q/q and +149% y/y.**
- **790 MW_{dc} of cells were imported in Q1 2023, up 13% q/q and 32% y/y.**
  - Despite the increase in PV cell imports in Q1 2023, as of May, PV cell imports are still on track to reach 2.5 GW_{dc} of the Section 201 quota despite the quota being raised to 5.0 GW_{dc} last year.

U.S. Module (c-Si + CdTe) Imports by Region Jan 2020-May 2023

According to U.S. Census data, 12.2 GW_{dc} of modules were imported in Q1 2023 (+1.8 $GW_{dc,}$ +17% q/q; 149% y/y), a fourth straight quarter of growth.

– This q/q growth was primarily driven by Malaysia, Thailand, and Cambodia. South Korea (8%) and India (6%) continue to be significant sources of modules as well, while Vietnam (29%, 2.5 GW_{dc}) remains the single largest source of imported modules.

Over the last several years, U.S. module imports have been impacted by the COVID-19 pandemic, actions intended to address ensure compliance with forced labor laws – namely the Hoshine Withhold Release Order (WRO) and the Uyghur Forced Labor Prevention Act (UFLPA), as well as an investigation into possible circumvention of anti-dumping and countervailing duties (AD/CVD). President Biden declared an emergency with respect to the energy supply last June and enacted various measures, part of which Congress attempted to overturn via Congressional Review Act (CRA) legislation which the President vetoed in May.



Sources: Imports by HTS code: 8541460015(2018-2021)/8541430010(2022-) and 8541460035(2018-2021)/8541430080(2022-), Second Quantity (watts) from the U.S. ITC DataWeb and the U.S. Census Bureau USA Trade Online tool and corrections page as of 7/25/23. Manual corrections were made to imports from India in due to suspected data entry errors.

c-Si Cell Import Data Q1 2023

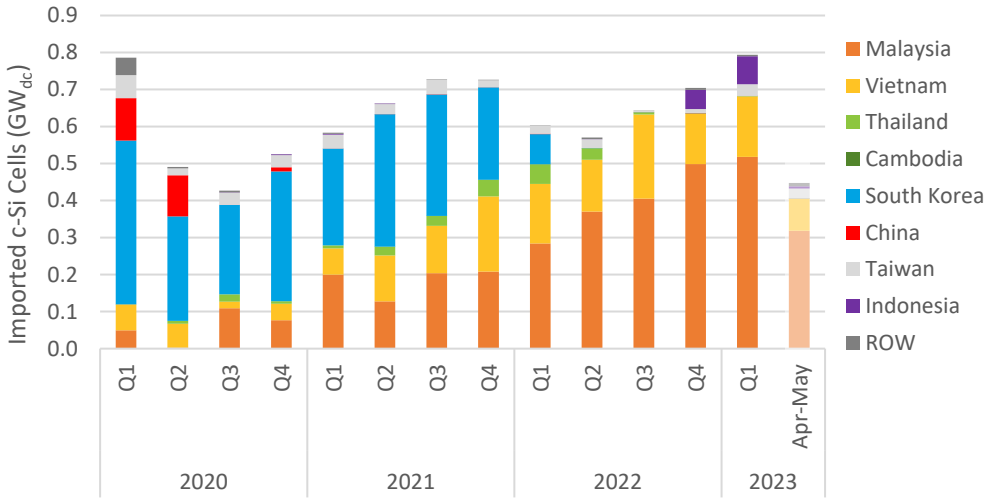
According to U.S. Census data, 790 MW_{dc} of cells were imported in Q1 2023. Quarterly cell imports grew for the third quarter in a row in Q1 2023 (+90 MW_{dc}, +13% q/q; +32% y/y).

- This growth was the result of increased imports across the board (Malaysia, Vietnam, Indonesia, and Taiwan).

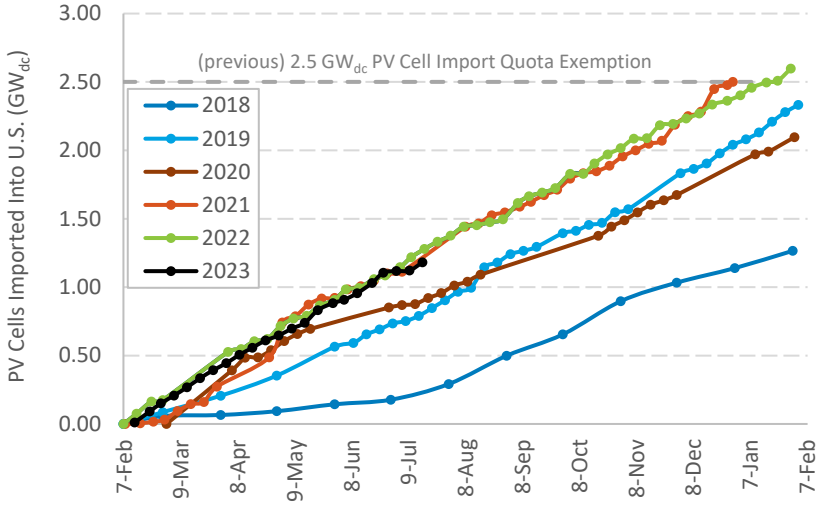
Though only April and May data are available, imports in Q2 2023 look to be slowing this growth trend.

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 Region



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 7/21/23; U.S. Customs and Border Protection Commodity Status Reports February 2019–July 2023.

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The next section provides a brief overview of Virtual Power Plants in the United States.

What's a Virtual Power Plant (VPP)? Elements

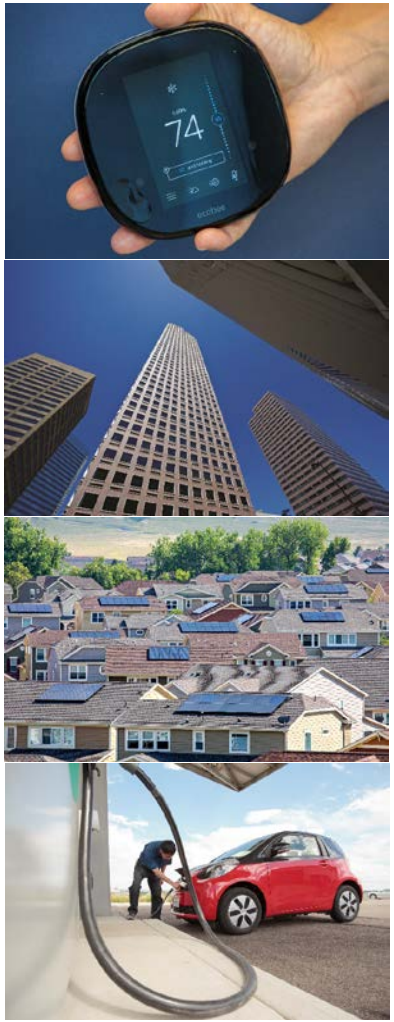
The elements of VPPs vary. The following elements are typical of U.S. VPPs:

- Multiple distributed energy resources (DERs):
  - Smart thermostats (mainly residential)
  - Direct load control (mainly C&I)
  - Batteries
  - PV
  - Electric vehicles and chargers
  - Other (e.g., generators, water heaters).

Used in more VPPs

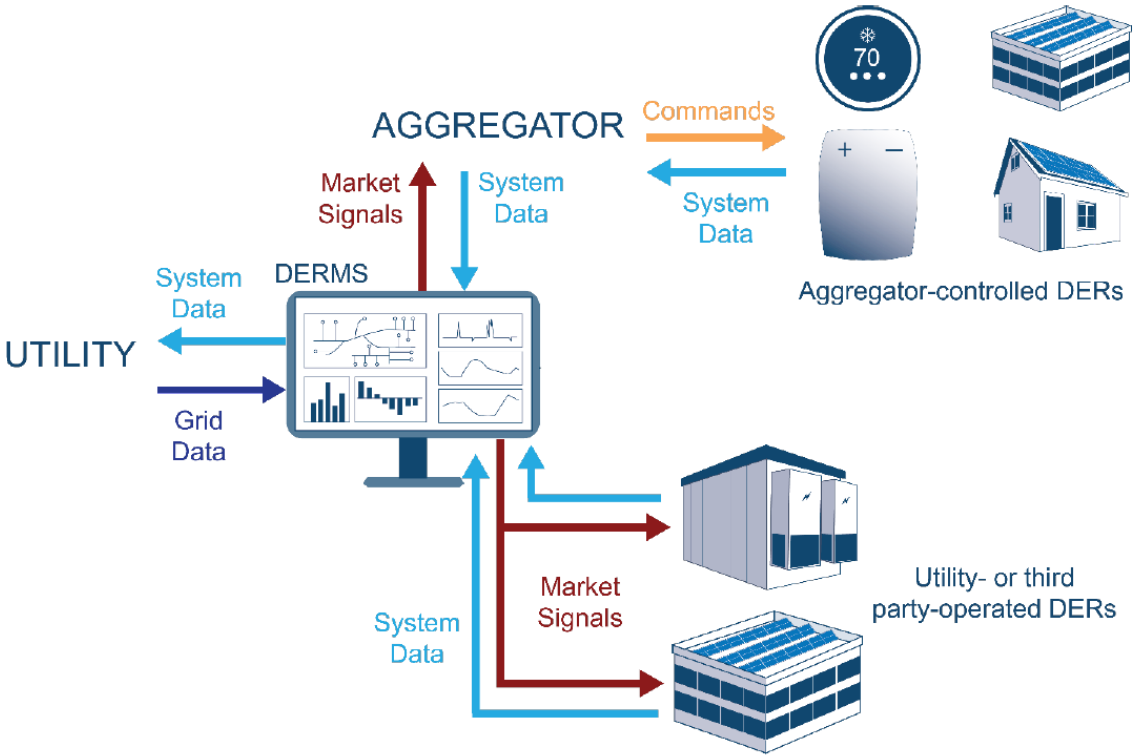
Used in fewer VPPs

- Technology platform for aggregating DERs
- Resource owners
- VPP operator
- Service territory.



Sources: BloombergNEF, Virtual Power Plant 101, June 2018; Wood Mackenzie, North America Virtual Power Plant (VPP) Market, H1 2023. NREL photos (from top): smart thermostat (Werner Slocum), commercial building (Dennis Schroeder), rooftop PV (Werner Slocum), EV smart charging pilot (Matthew Staver).

What's a VPP?
Example Data Flows

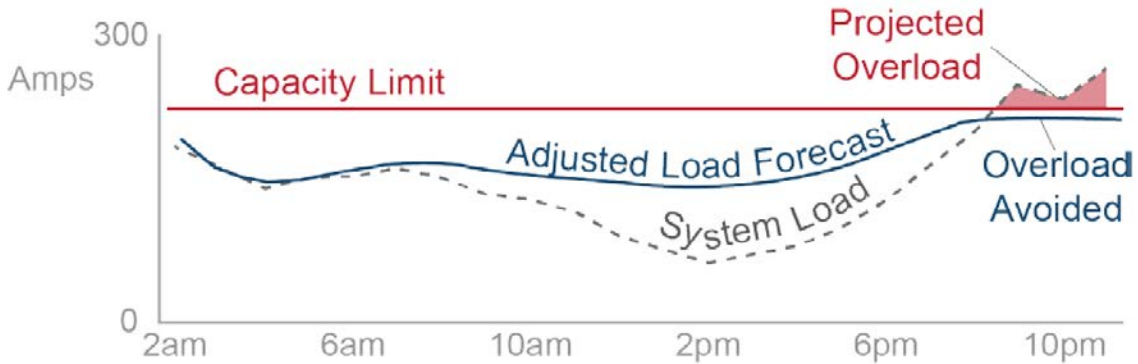


Source: Cook et al. (NREL), Expanding PV Value: Lessons Learned from Utility-led Distributed Energy Resource Aggregation in the United States, 2018.

What's a VPP? Functions

VPPs can perform various functions, including:

- Connect DER aggregations to markets and services
- Dispatch DERs to respond to signals for required flexibility
- Maximize benefits of diverse DER types to electricity system:
  - Network support (including Volt/VAR support)
  - Ancillary services
  - Peak management
  - Wholesale energy
  - Capacity and reliability.

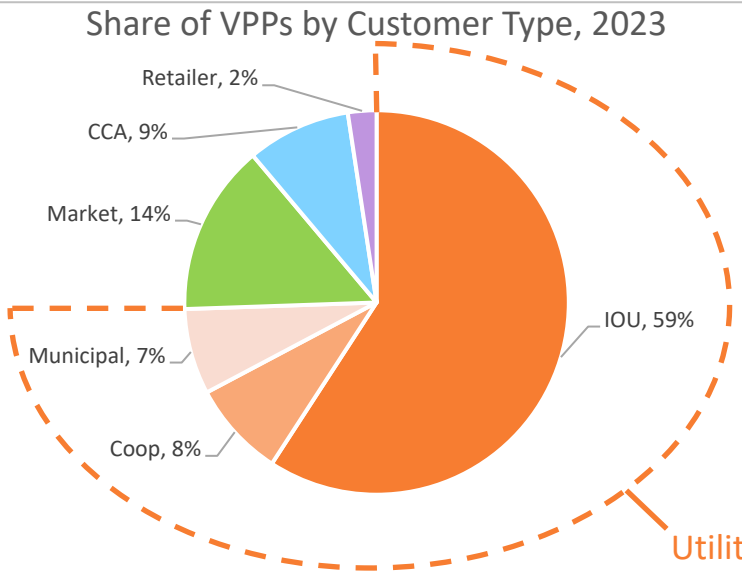


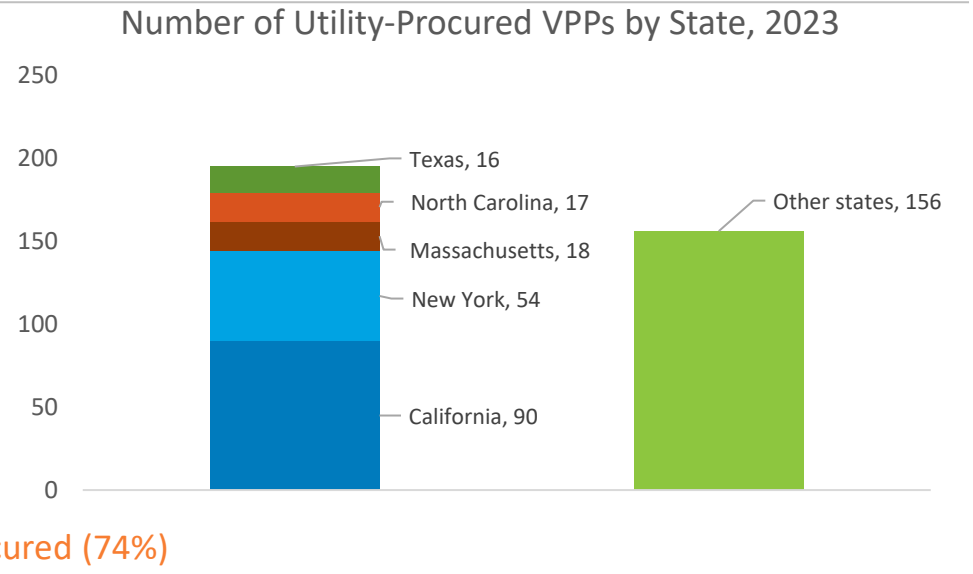
VPP demonstration avoiding system overload by charging batteries during peak generation and discharging during peak demand

Sources: BloombergNEF, Virtual Power Plant 101, June 2018; Cook et al. (NREL), Expanding PV Value: Lessons Learned from Utility-led Distributed Energy Resource Aggregation in the United States, 2018; Wood Mackenzie, North America Virtual Power Plant (VPP) Market, H1 2023.

Number of U.S. VPPs by Customer Type and State

- In the U.S., 74% of VPPs have been procured by utilities. The remainder have been procured for the wholesale market, community choice aggregation (CCA), and retailers.
- California has 25% of all utility VPPs, 41% of VPPs with energy storage, and 61% with electric vehicles (EVs).



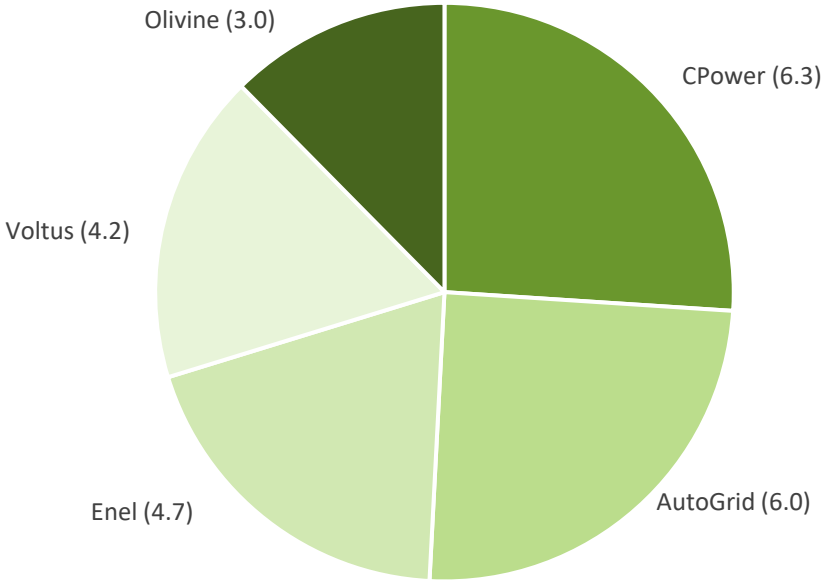


Source: Wood Mackenzie, North America Virtual Power Plant (VPP) Market, H1 2023.

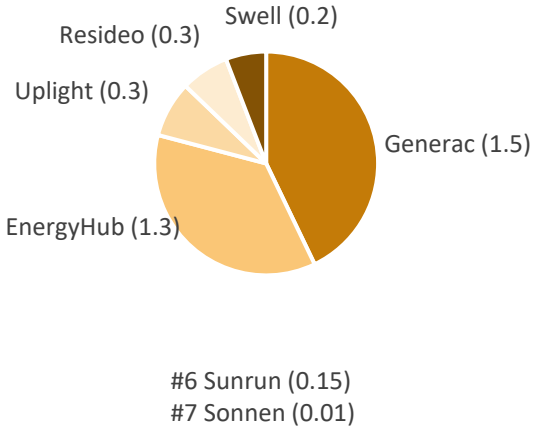
Capacity of U.S. VPPs by Sector & Top Portfolio Manager

- Of 7 VPP operators with > 1 GW under management, 5 primarily manage C&I resources.
- C&I scale allows direct access to markets; Federal Energy Regulatory Commission (FERC) Order 2222 will increase residential access.

Top 5 Primarily C&I (24.2 GW)



Top 5 Primarily Residential (3.6 GW)



Source: Wood Mackenzie, North America Virtual Power Plant (VPP) Market, H1 2023.

U.S. Federal VPP Policy: FERC Order 2222

- Passed in September 2020, full implementation is years away
- Enables aggregations of DERs to participate in organized wholesale capacity, energy, and ancillary services markets run by regional grid operators
- Applies to FERC-regulated areas (interconnection remains in state and local purview).

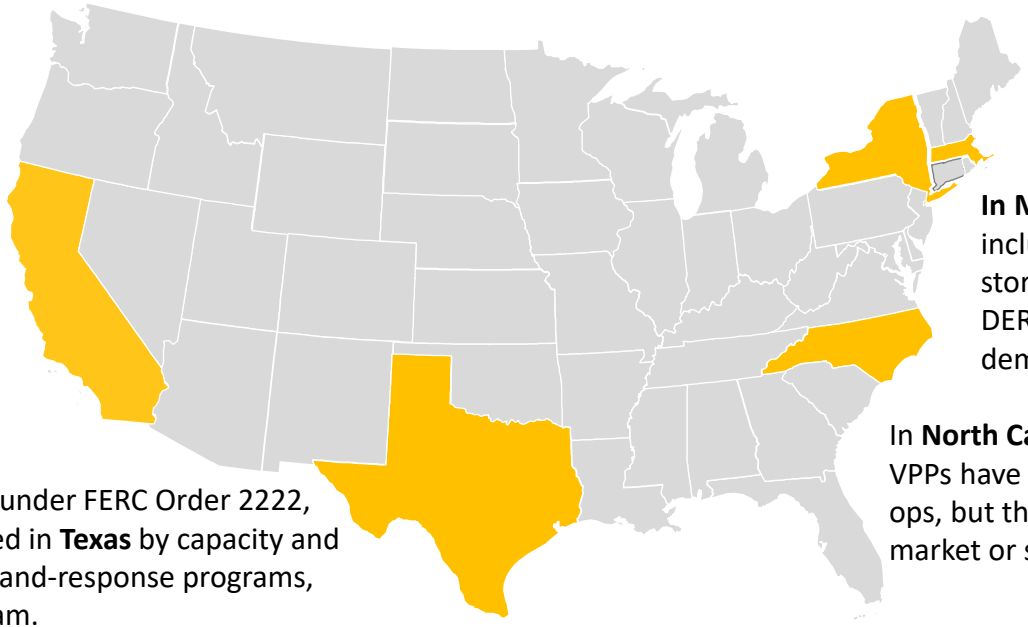
Market	Compliance Filing Status as of May 2023	Implementation Target
CAISO	Accepted June 2022 w/additional guidance	Q3 2022
ISO-NE	Partially accepted March 2023	Q4 2022 (fwd. capacity market), Q4 2026 (energy & ancillary svc.)
MISO	Filed April 2022, no FERC response	2030
NYISO	Partially accepted April 2023	Q4 2026
PJM	Filed April 2022, FERC revisions required	Q2 2023 (limited revisions), Q1 2026 (full implementation)
SPP	Filed April 2022, no FERC response	Q3 2025

Sources: BloombergNEF, The Business of Virtual Power Plant Companies, April 2022; Canary Media, FERC Order 2222: Experts offer cheers and jeers for first round of filings, March 2022; FERC, FERC Order No. 2222: Fact Sheet, September 2020; National Association of State Energy Officials, Overview of RTO/ISO Filing Status in Response to FERC Order 2222, May 2023 (working draft); Wood Mackenzie, North America Virtual Power Plant (VPP) Market, H1 2023.

Markets and Policies in Leading VPP States

Wholesale markets and supportive state programs are present in most of the leading VPP states.

California leads VPP activity with its resource adequacy market, DER capacity mandates, top residential PV market and battery attachment rate, and additional supportive policies.



New York mandates DER customer programs and capacity procurements, and NYISO has been a leader in DER integration.

In Massachusetts, policies include incentives for PV and storage as well as clean DERs that can reduce peak demands.

In **North Carolina**, peak-shaving VPPs have been established by co-ops, but there is no wholesale market or state support.

ERCOT is not covered under FERC Order 2222, but VPPs are supported in **Texas** by capacity and reserve markets, demand-response programs, and a VPP pilot program.

Sources: BloombergNEF, The Business of Virtual Power Plant Companies, April 2022; Canary Media, FERC Order 2222: Experts offer cheers and jeers for first round of filings, March 2022; Canary Media, Texans can now sign up for virtual power plant to help grid, make money, January 2023; FERC, FERC Order No. 2222: Fact Sheet, September 2020; Wood Mackenzie, North America Virtual Power Plant (VPP) Market, H1 2023.

Challenges to VPP Implementation

- **Difficulty realizing the full potential value of VPPs**
  - Utilities rarely recognize the full value stack of DERs.
  - Pursuing revenue outside of utilities requires complex combinations of programs and markets.
  - Flexibility markets can be shallow, competitive, and difficult for VPPs to access.
  - Export of excess DER energy to the grid is often uncompensated.
- **Lack of policy support**
  - FERC Order 2222 is being implemented slowly and is applicable only to FERC-regulated regions.
  - Many states provide little or no policy support for VPPs.
- **Constrained market access**
  - Direct constraints include partnership requirements, measurement and verification barriers, lack of utility data sharing, and high transaction costs related to registering and maintaining customers in VPP programs.
  - Competition from other flexible technologies such as utility-scale batteries can also constrain VPP access.
- **Adoption barriers**
  - Awareness of VPPs is low among customers and policymakers.
  - Customers can be slow to participate in VPPs owing to concerns such as degradation of EV batteries.
- **Difficulty coordinating transmission and distribution grids with the addition of VPPs**
- **Increased reliance on data will require more sophisticated communications and cybersecurity.**

Sources: BloombergNEF, The Business of Virtual Power Plant Companies, April 2022; RMI, Virtual Power Plants, Real Benefits, January 2023; Wood Mackenzie, North America Virtual Power Plant (VPP) Market, H1 2023.

Role of PV in VPPs

- **Because standalone PV is not dispatchable, its contribution to VPPs is limited.**
  - Solar energy can be sold into wholesale markets.
  - PV can provide limited benefits for network support and ancillary services.
  - It cannot shift demand peaks, and it is poorly suited to providing capacity and reliability.
- **PV plus storage is dispatchable and can contribute much more to VPPs.**
  - Suitable applications include providing network support, ancillary services, peak management, wholesale energy, and—with limited capability—capacity and reliability.
  - Increasing rates of attaching storage to PV systems and policies that encourage this practice (such as California's NEM 3.0 and Massachusetts' SMART incentives) will make more resources available to VPPs.
- **PV may enhance the value proposition of other DERs and thus drive distributed investments that increase the resources available to VPPs.**
  - Individuals and organizations purchasing PV-plus-storage systems for their own benefit (e.g., reducing utility bills, providing backup power) could benefit themselves and the grid by also participating in VPPs.
  - The addition of controllable loads to PV+storage can also enhance the value proposition.

Sources: BloombergNEF, Virtual Power Plant 101, June 2018; DOE, VPPiece #3: The Role of Photovoltaics and Li-ion Battery Storage, July 14, 2022; Wood Mackenzie, North America Virtual Power Plant (VPP) Market, H1 2023.

Thank You

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Special thanks to Nate Blair, Adam Warren, Jason Coughlin, Madeline Geocaris, Liz Breazeale and Samantha Wagstrom.

List of Acronyms and Abbreviations

AD: antidumping
ac: alternating current
ASP: average selling price
BGS: Boston Government Services, LLC
c-Si: crystalline silicon
C&I: commercial and industrial
CAISO: California Independent System Operator
CCA: Community Choice Aggregation
CBP: U.S. Customs and Border Protection
CdTe: cadmium telluride
CPI: consumer price index
CPUC: California Public Utility Commission
CRA: Congressional Review Act
CSP: concentrating solar power
CVD: countervailing
dc: direct current
DER: distributed energy resources
DPV: distributed photovoltaics
DOE: U.S. Department of Energy
EIA: U.S. Energy Information Administration
EPA: Environmental Protection Agency
ETF: exchange traded fund
EV: electric vehicle
FERC: Federal Energy Regulatory Commission
FOA: funding opportunity announcement
GGRF: Greenhouse Gas Reduction Fund
GW: gigawatt
GWh: gigawatt-hour
H1: first half of year
H2: second half of year
HJT: heterojunction technology
HOA: homeowners association
HTS: harmonized tariff schedule
IEA: International Energy Agency
IRA: Inflation Reduction Act of 2022
IREC: Interstate Renewable Energy Council
IRS: Internal Revenue Service
ISO-NE: ISO New England
ITC: investment tax credit
kW: kilowatt
kWh: kilowatt-hour
LCOE: levelized cost of energy
MESC: Office of Manufacturing and Energy Supply Chains
MISO: Midcontinent Independent System Operator
MPTC: manufacturing production tax credit
MW: megawatt
MWh: megawatt-hour
NEM: net energy metering
NREL: National Renewable Energy Laboratory
NYISO: New York Independent System Operator
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
SPP: Southwest Power Pool
SHJ: silicon heterojunction cells
TAN: Invesco Solar ETF
TOPCon: tunnel oxide passivated contact
TW: terawatt
TWh: terawatt-hour
UFLPA: Uyghur Forced Labor Prevention Act
UPV: utility-scale photovoltaics
USD: U.S. dollars
USEER: United States Energy & Employment Jobs Report
VPP: virtual power plant
W: watt
WRO: Withhold Release Order
Wt avg: weighted average
y/y: year over year
YTD: year to date

Manufacturing Announcement Links

post-IRA?	company	link
Y	Adion Solar	https://www.solarpowerworldonline.com/2022/12/georgia-adion-solar-500-mw/
Y	Alpha Steel	https://www.pv-tech.org/ftc-solar-taihua-set-up-us-based-jv-to-produce-steel-components-for-solar-projects/
N	Atkore (Nextracker)	https://taiyangnews.info/business/nextracker-commission-manufacturing-line-in-arizona/
N	BCI Steel (Nextracker)	https://taiyangnews.info/business/steel-fab-reopens-in-us-for-nextracker/
Y	Canadian Solar	https://seekingalpha.com/article/4559827-canadian-solar-inc-csiq-q3-2022-earnings-call-transcript
N	Convalt Energy	https://www.solarpowerworldonline.com/2021/07/convalt-energy-to-open-700-mw-solar-panel-assembly-facility-in-new-york-in-2022/
N	Convalt Energy	https://finance.yahoo.com/news/convalt-plans-second-manufacturing-plant-120300294.html
Y	Convalt Energy	https://www.solarpowerworldonline.com/2022/08/convalt-energy-solar-panel-factory-in-new-york-now-scheduled-to-open-in-mid-2023/
Y	Cubic PV	https://cubicpv.com/cubicpv-announces-plans-to-build-silicon-wafer-facility-in-the-united-states/
Y	Endurans Solar	https://taiyangnews.info/business/us-solar-backsheet-maker-expanding-capacity/
Y	Enel/3Sun USA	https://www.enelnorthamerica.com/newsroom/news/search-press/press/2022/11/solar-panel-manufacturing
Y	Enphase Energy	https://taiyangnews.info/business/enphase-energy-to-open-manufacturing-lines-in-us/
Y	Enphase Energy/Flex	https://www.solarpowerworldonline.com/2023/07/enphase-begins-us-inverter-manufacturing-with-contract-partner/
Y	EPC Power	https://governor.sc.gov/news/2022-11/epc-power-establishing-operations-greenville-county
Y	First Solar	https://pv-magazine-usa.com/2022/08/30/breaking-first-solar-to-invest-up-to-1-2-billion-in-expanding-u-s-solar-manufacturing-by-4-4-gw/?utm_source=USA+%7C+Newsletter&utm_campaign=23d2bb1f2f-RSS_EMAIL_CAMPAIGN&utm_medium=email&utm_term=0_80e0d17bb8-23d2bb1f2f-160130709
Y	First Solar	https://pv-magazine-usa.com/2023/07/27/first-solar-announces-fifth-u-s-solar-panel-manufacturing-facility/?utm_source=USA+%7C+Newsletter&utm_campaign=4a23866487-RSS_EMAIL_CAMPAIGN&utm_medium=email&utm_term=0_80e0d17bb8-4a23866487-160130709
Y	Fuyao	https://taiyangnews.info/business/fuyao-glass-to-expand-production-capacity-in-the-us/
N	GAF Energy	https://pv-magazine-usa.com/2022/07/19/gaf-energy-to-open-solar-tile-manufacturing-facility-in-texas/?utm_source=USA+%7C+Newsletter&utm_campaign=756ed38141-RSS_EMAIL_CAMPAIGN&utm_medium=email&utm_term=0_80e0d17bb8-756ed38141-160130709
N	GameChange Solar	https://taiyangnews.info/business/usa-6-gw-solar-tracker-manufacturing-fab/
Y	Hanwha Advanced Materials Georgia (HAGA)	https://taiyangnews.info/business/hanwha-solutions-corporation-to-restructure-business/
N	Heliene	https://www.minnpost.com/greater-minnesota/2021/09/the-iron-range-may-soon-be-home-to-one-of-the-largest-solar-panel-manufacturing-facilities-in-the-country/
Y	Heliene	https://www.pv-tech.org/heliene-president-opens-up-on-us-manufacturing-plans-post-ira/
Y	Hounen	https://governor.sc.gov/news/2023-03/hounen-solar-establishing-first-us-manufacturing-operations-orangeburg-county
N	Ice Industries	https://www.wtol.com/article/tech/ice-industries-new-plant-bowling-green-to-supply-first-solar/512-ddea5416-2ca2-446b-8743-2aa41f0d165a
Y	Illuminate USA	https://www.dispatch.com/story/business/economy/2023/03/10/the-factory-comes-as-ohio-ramps-up-solar-farm-construction/69995223007/
Y	JA Solar	https://www.pv-magazine.com/2023/01/11/ja-solar-plans-to-build-2-gw-solar-module-factory-in-us/

Manufacturing Announcement Links

N	JM Steel (Nextracker)	https://www.pv-tech.org/nextracker-opens-manufacturing-line-in-texas-to-counter-supply-chain-disruptions/
Y	Linton Crystal	https://solarbuildermag.com/news/linton-crystal-technologies-to-produce-solar-ingot-wafer-equipment-in-united-states/
Y	Lock Joint Tube (Array Technologies)	https://solarindustrymag.com/array-technologies-lock-joint-tube-team-up-on-texas-steel-tube-mill
N	Maxeon	https://www.solarpowerworldonline.com/2021/04/maxeon-solar-might-open-a-1-8-gw-solar-panel-assembly-plant-in-the-united-states/
N	Meyer Burger	https://www.pv-magazine.com/2021/09/29/meyer-burger-to-open-400-mw-solar-module-factory-in-us/
Y	Meyer Burger	https://pv-magazine-usa.com/2023/05/30/meyer-burger-considers-u-s-solar-cell-manufacturing-in-talks-with-sunrun-sunnova/
Y	Mission Solar/OCI	https://www.kedglobal.com/energy/newsView/ked202210240009
Y	Mitrex Solar	https://sustainablebiz.ca/mitrex-design-engineering-new-us-facility
Y	MSS Steel Tubes (Nextracker)	https://www.commercialappeal.com/story/money/business/development/2023/02/08/mss-steel-tubes-usa-first-us-plant-memphis-tennessee/69885255007/
N	NanoPV	https://gov.georgia.gov/press-releases/2021-10-07/gov-kemp-solar-tech-company-nanopv-open-manufacturing-distribution
Y	Norsun	https://taiyangnews.info/business/european-integrated-pv-manufacturing-at-scale/
N	OMCO Solar	https://omcosolar.com/omco-solar-is-serious-about-american-manufacturing-with-additional-5-million-investment/
Y	OMCO Solar	https://omcosolar.com/omco-solar-expands-domestic-manufacturing-with-second-torque-tube-production-line-announces-fifth-factory-in-indiana/
N	Philadelphia Solar	https://www.enfsolar.com/news/17753/philadelphia-solar-announces-1-gw-pv-panel-manufacturing-facility-investment-plan-in-u-s
Y	Polar Racking	https://pv-magazine-usa.com/2023/05/19/polar-racking-adds-two-u-s-solar-mount-manufacturing-facilities/
Y	Prolec	https://www.ksla.com/2023/04/25/prolec-ge-announces-multi-million-dollar-expansion-caddo-parish-facility/
Y	PV Hardware	https://www.pv-tech.org/pv-hardware-plans-6gw-solar-tracker-manufacturing-factory-in-texas/
Y	Qcells	https://www.nytimes.com/2023/01/11/business/energy-environment/qcells-solar-panel-factory-georgia.html
N	Qcells	https://www.pv-magazine.com/2022/05/12/hanwha-q-cells-plans-another-big-solar-module-factory-in-the-us-expands-cell-capacity-in-korea/
Y	Rayzon Solar	https://www.devdiscourse.com/article/technology/2397753-indian-giga-factory-rayzon-solar-now-to-manufacture-and-produce-solar-panels-in-the-usa
N	REC Silicon	https://www.pv-tech.org/rec-silicon-to-restart-production-in-moses-lake-at-q4-2023/
N	Reliance	https://pv-magazine-usa.com/2021/10/11/reliance-industries-acquires-rec-group-plans-1-gw-u-s-module-facility/
Y	Revkor/H2 Gemini	https://www.prnewswire.com/news-releases/revkor-energy-holdings--partnership--h2-gemini-301881311.html

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Y	Runergy	https://taiyangnews.info/opinion/snec-exclusive-runergy-executive-interview/
Y	Saatvik	https://www.pv-magazine-india.com/2023/04/13/saatvik-establishes-us-subsidiary/
Y	SEG Solar	https://taiyangnews.info/business/new-n-type-topcon-solar-module-fab-in-texas-us/
Y	Silfab	https://www.solarpowerworldonline.com/2022/05/silfab-united-states-solar-cell-manufacturing-halted-by-commerce-decision/
N	SolarEdge	https://www.renewableenergyworld.com/solar/solaredge-plans-u-s-manufacturing-expansion-thanks-to-ira/#gref
Y	SPI Energy/Solar4America	https://www.yahoo.com/now/spi-energy-accelerates-growth-solar-074500666.html
N	SPI Energy/Solar4America	https://www.spigroups.com/spi-energys-solarjuice-technology-starting-production-expanding-solar-module-manufacturing-capacity-to-1-1gw-at-sacramento-facility/
Y	SPI Energy/Solar4America	https://www.accesswire.com/767253/SPI-Energys-Solar4america-Technology-Announces-N-Type-Heterojunction-Technology-HJT-Solar-Cell-Factory-in-the-US
Y	SPI Energy/Solar4America	https://www.accesswire.com/757920/SPIs-Solar4america-Announces-New-500MW-N-Type-TOPCon-Solar-Cell-Manufacturing-Facility-in-the-US
Y	SPI Energy/SEM Wafertech	https://www.solarpowerworldonline.com/2022/08/spi-energy-will-start-1-5-gw-silicon-wafer-manufacturing-site-stateside-by-2023/
N	Sun Pacific/PT.IDN Solar Tech	https://www.roi-nj.com/2022/04/20/industry/energy-utilities/sun-pacific-to-develop-a-u-s-solar-panel-manufacturing-facility/
Y	Terabase	https://www.businesswire.com/news/home/20230511005315/en/Terabase-Energy-Launches-Terafab-Automated-Field-Factory-to-Accelerate-the-Deployment-of-Solar-Power-Plants
Y	Thornova (Sunova)	https://pv-magazine-usa.com/2023/07/25/vietnamese-solar-modules-for-u-s-projects/
Y	Toledo Solar	https://taiyangnews.info/business/toledo-solar-to-expand-us-manufacturing-capacity/
N	Ubiquity Solar	https://www.governor.ny.gov/news/governor-hochul-announces-plans-ubiquity-solar-establish-us-manufacturing-operations-former
Y	UKT New Energy (SEG Solar)	https://pv-magazine-usa.com/press-releases/seg-solar-and-ukt-new-energy-establish-strategic-partnership-to-build-junction-box-factory-in-houston-texas/
Y	VSK (Vikram, Phalanx, Das & Co)	https://www.reuters.com/business/energy/group-backed-by-indias-vikram-solar-invest-15-billion-new-us-factories-2023-06-22/
Y	Vitro Glass	https://www.usglassmag.com/2023/04/vitro-enters-agreement-with-first-solar-to-manufacture-glass-for-solar-panels/
Y	Waaree Energies	https://news.bloombergtax.com/daily-tax-report/bidens-climate-push-lures-indian-firm-to-make-panels-in-us
Y	Runergy	https://taiyangnews.info/opinion/snec-exclusive-runergy-executive-interview/
Y	Saatvik	https://www.pv-magazine-india.com/2023/04/13/saatvik-establishes-us-subsidiary/
Y	SEG Solar	https://taiyangnews.info/business/new-n-type-topcon-solar-module-fab-in-texas-us/
Y	Silfab	https://www.solarpowerworldonline.com/2022/05/silfab-united-states-solar-cell-manufacturing-halted-by-commerce-decision/