

# Summer 2024

## Solar Industry Update

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August 20, 2024

# Agenda

**1** **Global Solar Deployment**

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**2** **U.S. PV Deployment**

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**3** **PV System Pricing**

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**4** **Global Manufacturing**

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**5** **Component Pricing**

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**6** **Market and Policy**

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

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# Executive Summary

## Global Solar Deployment

- About 560 GW<sub>dc</sub> of global PV installations are projected for 2024, up about a third from 2023.
- The five leading solar markets in 2023 kept pace or increased PV installation capacity in the first half of 2024, with China installing more than 100 GW<sub>dc</sub> and India installing more solar in the first half of 2024 than it did for all of 2023.
- At the end of 2023, global CSP capacity reached approximately 7 GW<sub>ac</sub>, with the completion of the Noor Energy 1 project in the United Arab Emirates.

## U.S. PV Deployment

- EIA reported that the United States installed 15.6 GW<sub>ac</sub> of solar capacity in Q1/Q2 2024 (SEIA reported 21.4 GW<sub>dc</sub>)—a 55% increase from the record achieved in Q1/Q2 2023.
  - The residential PV market shrank significantly in the first half of 2024, hurt by California’s NEM transition and high interest rates across the country.
- Analysts expect about 42 GW<sub>dc</sub> of U.S. PV installations for 2024, up about a quarter from 2023.
- The United States installed approximately 3.5 GWh (1.3 GW<sub>ac</sub>) of energy storage onto the electric grid in Q1 2024—its largest first quarter on record, though significantly lower than installations in the previous three quarters.
- At the end of 2023, more than 360,000 U.S. employees spent some of their time on solar, mostly in the construction sector—a growth of 5.3% y/y.

## PV System and Component Pricing

- In Q3 2024, the average global factory gate module price dropped another 10%, reaching \$0.10/W<sub>dc</sub>, with some module prices falling below production costs.

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

- Global polysilicon spot prices fell 10% from early May (\$6.20/kg) to late July (\$5.58/kg), the lowest price over the past decade, before increasing 1% (\$5.66/kg) in early August. During the same period, global prices decreased for wafers (18%) and cells (11%).
- In Q1 2024, the average U.S. module price (\$0.33/W<sub>dc</sub>) was up 5% q/q and down 8% y/y – This is a 200% premium over the global spot price for monofacial monocrystalline silicon modules.
- In Q2 2024, the average imported PV cell price was \$0.15/W<sub>dc</sub>.

## Global Manufacturing

- Despite record levels of module shipments from leading companies, margins from PV manufacturers, on average, remain below historical averages due to record low global pricing.
- Since the IRA’s passage, more than 85 GW of manufacturing capacity have been added across the solar supply chain (from facilities announced pre- and post-IRA) out of 335 GW announced, including nearly 35 GW of new module capacity.

## U.S. PV Imports

- In August, the United States increased the quota for tariff-free silicon solar cell imports from 5 GW to 12.5 GW<sub>dc</sub>, while a U.S. solar group asked Commerce to place retroactive duties on Vietnamese/Thai imports.
- According to U.S. Census data, in Q2 2024, U.S. module imports grew again to nearly 18 GW<sub>dc</sub> (+17% q/q), or 33 GW<sub>dc</sub> for the first half of 2024.
- After several years of relatively steady import volumes, c-Si cell imports have begun to rise substantially as new domestic module manufacturing capacity comes online. According to U.S. Census data, the United States imported more than 3 GW<sub>dc</sub> of cells in Q2 2024—the fourth straight quarter of growth (and third straight 50%+ q/q). NREL | 3

# Agenda

## 1 Global Solar Deployment

## 2 U.S. PV Deployment

## 3 PV System Pricing

## 4 Global Manufacturing

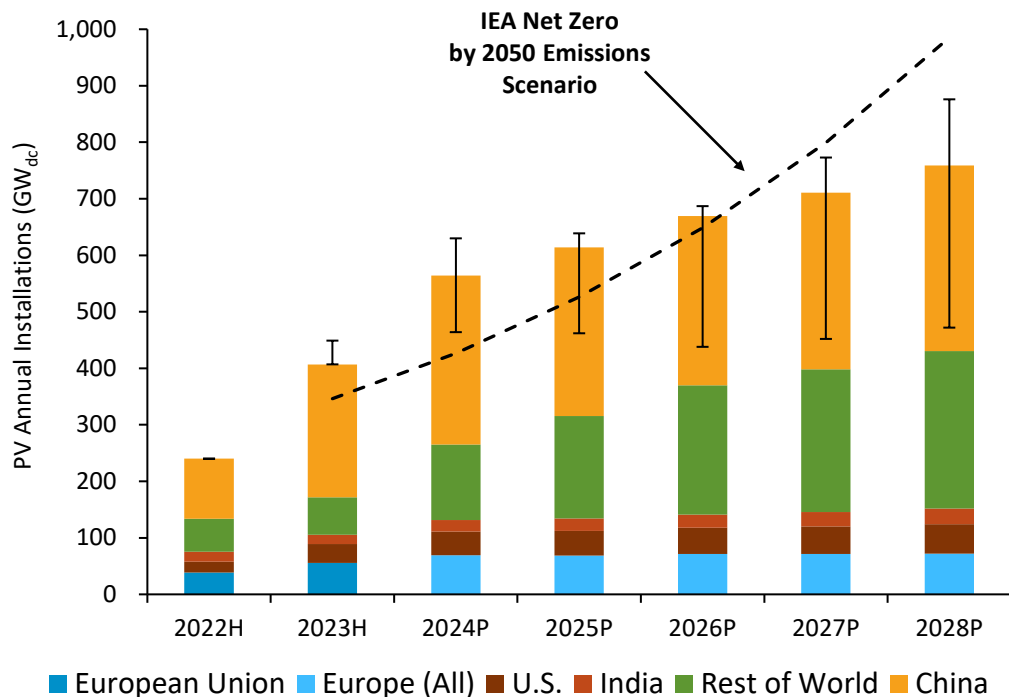
## 5 Component Pricing

## 6 Market and Policy

## 7 U.S. PV Imports

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- The five leading solar markets in 2023 kept pace or increased PV installation capacity in the first half of 2024, with China installing more than 100 GW<sub>dc</sub> and India installing more solar in the first half of 2024 than it did for all of 2023.
- At the end of 2023, global CSP capacity reached approximately 7 GW<sub>ac</sub>, with the completion of the Noor Energy 1 project in the United Arab Emirates.

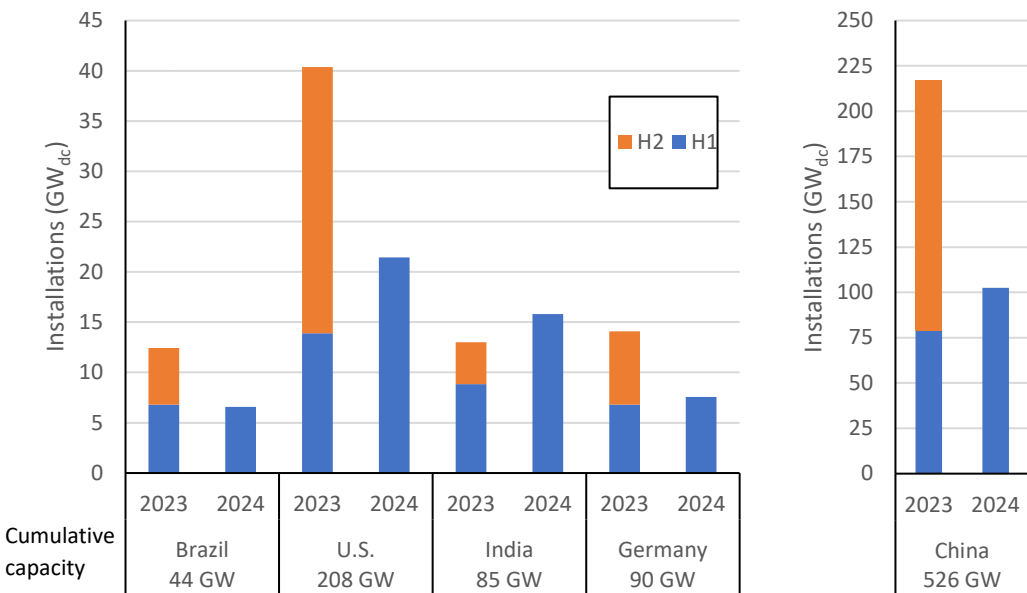
# Annual Global PV Deployment



- About 560 GW<sub>dc</sub> of global PV installations are projected for 2024, up about a third from 2023.
- Analysts project continued increases in annual global PV installations:
  - 610 GW<sub>dc</sub> in 2025 (+9% y/y)
  - 670 GW<sub>dc</sub> in 2026 (+9% y/y)
  - 710 GW<sub>dc</sub> in 2027 (+6% y/y)
  - 760 GW<sub>dc</sub> in 2028 (+7% y/y).
- Among analysts covered in the Winter 2024 edition of the *Solar Industry Update*, global projections increased in this edition, e.g., by 20%–33% for 2027.
- The range between high and low projections grows from about 170 GW<sub>dc</sub> in 2024 to 400 GW<sub>dc</sub> in 2028.
- Over the period shown, China is projected to install the most PV (47%), followed by Europe (11%), the United States (7%), and India (4%).
- In 2028, the median analyst projection falls 230 GW<sub>dc</sub>/y short of the trajectory in the International Energy Agency (IEA) Net Zero Emissions by 2050 scenario.

**Notes:** H = historical; P = projection. Bar totals represent median global projections across analysts who provide a global projection. Error bars represent high and low global projections. Regional bar segments represent medians of all available regional projections. Where regional medians do not sum to global medians, the differences are reconciled by adjusting the Rest of World segments so that the correct global median values are retained. IEA values in GW<sub>ac</sub> are converted to GW<sub>dc</sub> using a DC-to-AC ratio of 1.3. **Sources:** Bernreuter Research, “[PV Installations Will Reach up to 660 GW in 2024](#),” 6/18/24; BNEF, 2Q 2024 Global PV Market Outlook, 5/23/24; IEA, [Snapshot of Global PV Markets: 2024, 4/24](#); IEA, [Net Zero by 2050](#), May, 2021; SolarPower Europe, [Global Market Outlook for Solar Power 2024–2028](#), 6/24; Wood Mackenzie, Q3 2024 Solar Executive Briefing, 6/24.

# International Q1/Q2 2024 Installations



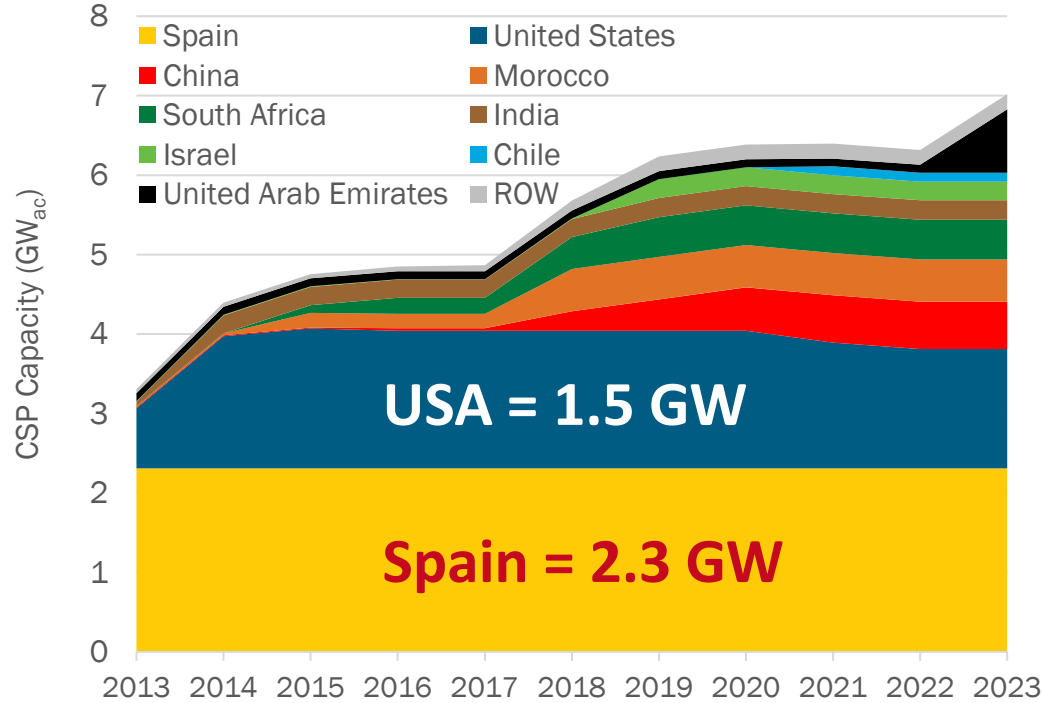
- The five leading solar markets in 2023 kept pace or increased PV installation capacity in the first half of 2024 y/y:
  - China Q1/Q2 2024 installations grew 31%, to more than 100 GW<sub>dc</sub>.
  - India installed more solar in the first half of 2024 than it did for all of 2023, 82% of which was utility-scale.
    - The Indian government postponed the mandate for solar projects to use domestic manufacturers until the end of its fiscal year in March, causing a surge in Q1 installations. Analysts attributed lower than expected 2023 installations to the mandate (i.e., ALMM).
- At the end of June, these countries had cumulatively installed more than 950 GW<sub>dc</sub> of PV.

**Note:** India installations are translated from GW<sub>ac</sub> to GW<sub>dc</sub> using an inverter loading ratio of 1.3.  
**Sources:** ABSolar ([08/13/24](#)); Hindu Business Online ([07/12/24](#)); Mercom (11/27/23); PV Magazine ([08/11/23](#), [08/13/24](#), [01/10/24](#)); PVTech ([07/23/24](#), [07/17/24](#)); Wood Mackenzie/SEIA: [U.S. Solar Market Insight: Q3 2024](#).

# Concentrating Solar Power Update

- In July, the [world's first dual tower CSP plant began its commissioning process](#). The 100-MW<sub>ac</sub> Three Gorges CSP project has two towers, two fields, and one power block. The two 50-MW<sub>ac</sub> towers and field, as opposed to one 100-MW<sub>ac</sub> tower and field, reduce “optical attenuation,” which decreases the efficiency of heliostats farther from a tower.
  - Conversely, in March, Power China announced that it had [begun construction of the world's only 200-MW<sub>ac</sub> solar tower](#)—twice the normal size.
- In Germany in June, [Synhelion inaugurated the world's first industrial-scale plant to produce synthetic fuels using solar heat](#) and is expected to start production this year. Using a 20-meter solar tower, the plant will produce several thousands of liters of synthetic crude oil per year, which will then be processed further at a traditional oil refinery. The company intends to build a much larger plant in Spain next year, which can produce 1,000 tons of fuel per year, and to expand to 1M tons of solar fuel within 10 years. A large airplane uses approximately 10–11 tons of fuel per hour.
- Chinese CSP manufacturer Cosin Solar was awarded another [100-MW<sub>ac</sub> equipment supply agreement in July](#), bringing its pipeline to approximately [1.5 GW<sub>ac</sub> of projects](#).
- In March, [India issued a 500-MW<sub>ac</sub> tender for CSP projects](#).

# Global CSP Capacity (Operational)



At the end of 2023, global CSP capacity reached approximately 7 GW<sub>ac</sub>, with the completion of the Noor Energy 1 project in the United Arab Emirates.

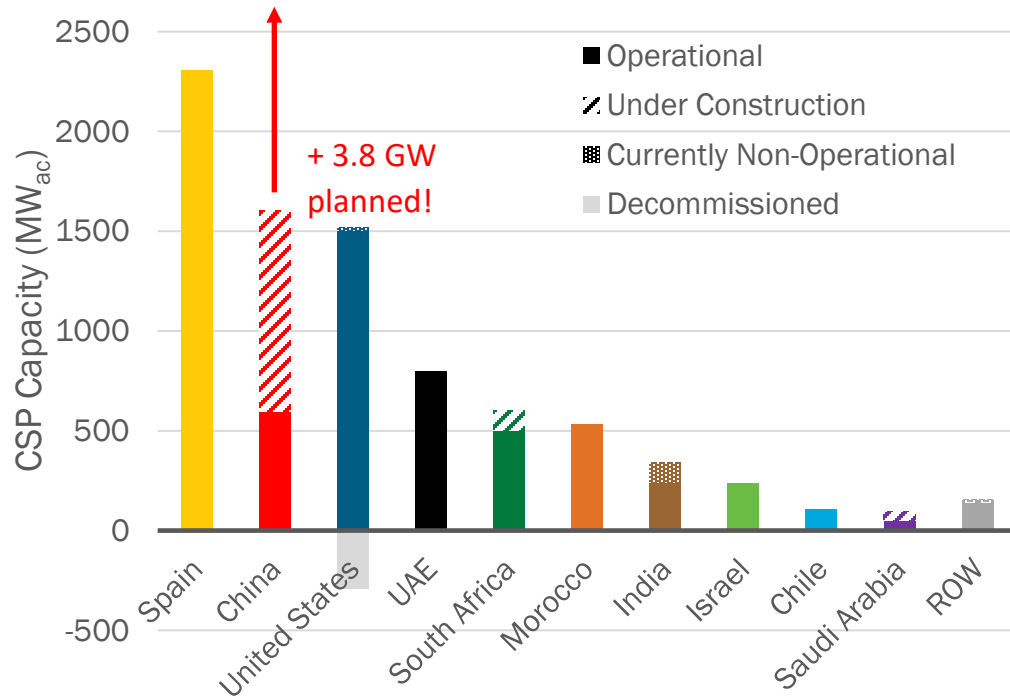
- Noor Energy 1 came online in 2023 and is the world's largest CSP plant, with 700 MW<sub>ac</sub> of CSP capacity!
- It uses second-generation CSP technology, including large-aperture parabolic troughs (600 MW<sub>ac</sub>) and a molten-salt tower (100 MW<sub>ac</sub>) with >10 hours of thermal storage in hot and cold tanks, and includes PV generation (250 MW<sub>ac</sub>).

Spain continued to have the largest installed CSP capacity at 2.3 GW<sub>ac</sub>, followed by the United States with 1.5 GW<sub>ac</sub>.

Sources: [REN21](#). 2024. Renewables 2024 Global Status Report Collection – [Energy Supply](#). Thonig, Richard, Alina Gilmanova, and Johan Lilliestam. 2023. CSP.guru 2023-07-31 [Data set]. Zenodo. <https://zenodo.org/doi/10.5281/zenodo.1318151>.



# Global CSP Capacity (Planned)



At the end of 2023, global CSP planned capacity was over 8 GW<sub>ac</sub>, with expansion planned in China, South Africa, and Saudi Arabia.

At the end of 2023, China had 600 MW<sub>ac</sub> of CSP in operation. It also had 1 GW<sub>ac</sub> of CSP under construction and 3.8 GW<sub>ac</sub> of CSP planned (43 plants in total).

- 1.2 GW<sub>ac</sub> of that capacity is expected to be online by the end of 2024, with the rest expected in 2025.

The United States also remains the only nation to have decommissioned large-scale CSP generation, which were the Solar Energy Generating System (SEGS) I-VIII projects.

Sources: [REN21](#). 2024. Renewables 2024 Global Status Report Collection – [Energy Supply](#). Chinese Solar Thermal Alliance. [Blue Book of China's Concentrating Solar Power Industry 2023](#). Feb 2024. Thonig, Richard, Alina Gilmanova, and Johan Lilliestam. 2023. CSP.guru 2023-07-31 [Data set]. Zenodo. <https://zenodo.org/doi/10.5281/zenodo.1318151>.

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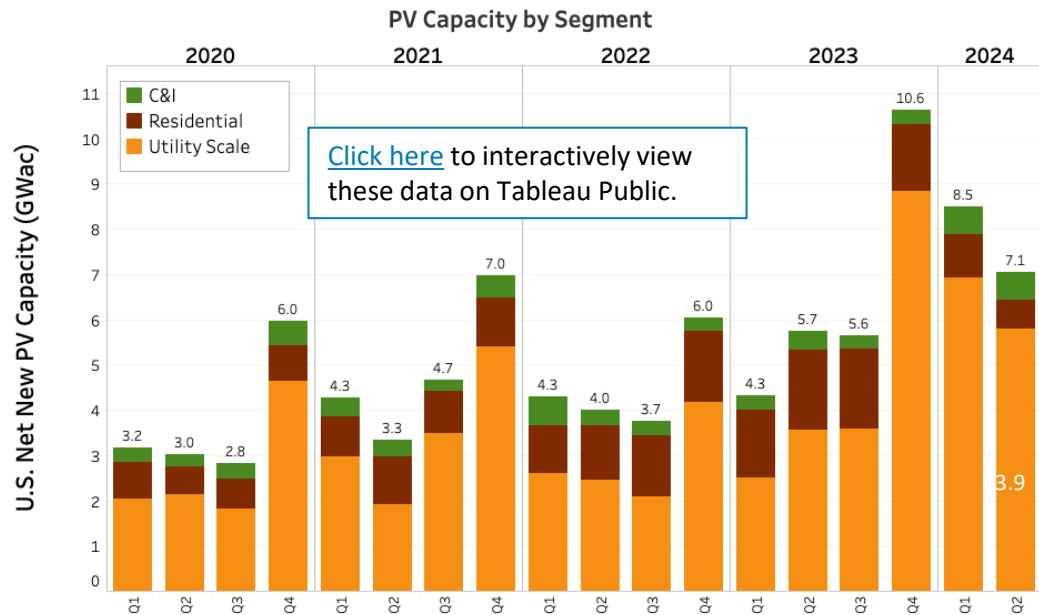
## 7 U.S. PV Imports

- EIA reported that the United States installed 15.6 GW<sub>ac</sub> of solar capacity in the first half of 2024 (SEIA reported 21.4 GW<sub>dc</sub>)—a 55% increase from the record achieved in the first half of 2023.
  - The residential PV market shrank significantly in the first half of 2024, hurt by California’s NEM transition and high interest rates across the country.
- Analysts expect about 42 GW<sub>dc</sub> of U.S. PV installations for 2024, up about a quarter from 2023.
- The United States installed approximately 3.5 GWh (1.3 GW<sub>ac</sub>) of energy storage onto the electric grid in Q1 2024—its largest first quarter on record, though significantly lower than installations in the previous three quarters.
- At the end of 2023, more than 360,000 U.S. employees spent some of their time on solar, mostly in the construction sector—a growth of 5.3% y/y.

# U.S. Installation Breakdown Quarterly: EIA (GW<sub>ac</sub>)

- In the first half of 2024, the United States installed 15.6 GW<sub>ac</sub> of solar capacity—a 55% increase from the record achieved in the first half of 2023.

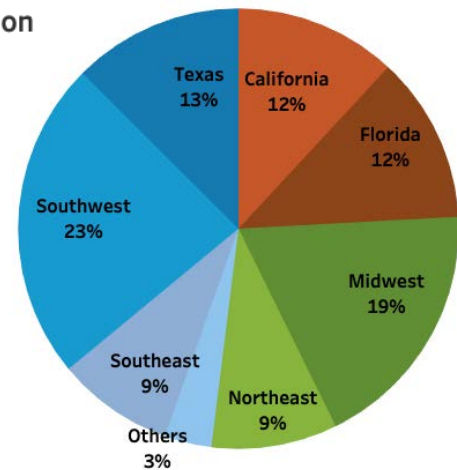
- Residential (1.6 GW<sub>ac</sub>) was down 52%; however, utility-scale (12.7 GW<sub>ac</sub>) and C&I (1.2 GW<sub>ac</sub>) were up 111% and 76%, respectively.
- EIA reported that Texas, Florida, and California continued to lead the way; however, they represented a much smaller percentage of the total market (37%) than in past years.
  - Six states installed more than 1 GW<sub>ac</sub> in the first half of 2024 and 20 more each installed more than 100 MW<sub>ac</sub>.



## PV Installations by Region

Total: 15.54 GW<sub>ac</sub>  
1/1/2024 - 6/1/2024

Click [here](#) to interactively view these data on Tableau Public.



**Note:** EIA reports values in W<sub>ac</sub>, which is standard for utilities. The solar industry has traditionally reported in W<sub>dc</sub>. See the next slide for values reported in W<sub>dc</sub>.

**Sources:** EIA, [Electric Power Monthly](#), forms EIA-023, EIA-826, and EIA-861 (August 2024, February 2024).

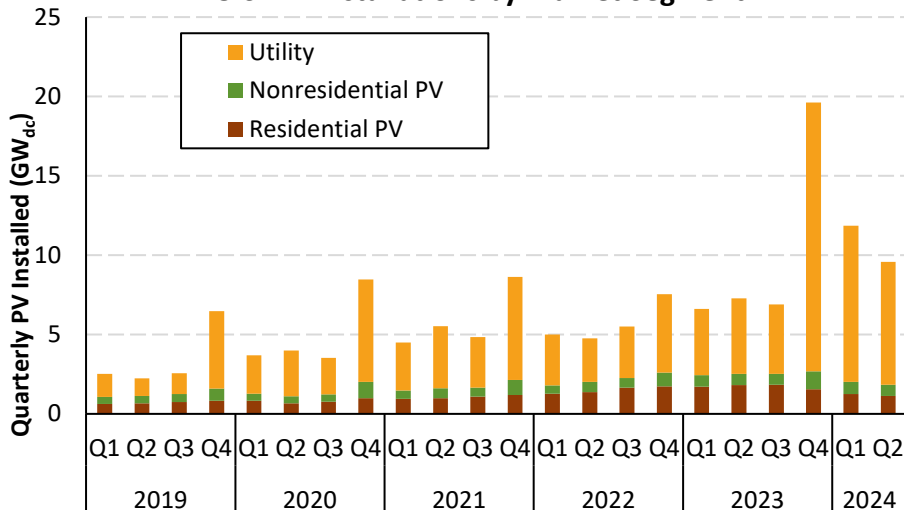
# U.S. Installation Breakdown Quarterly: SEIA ( $GW_{dc}$ )

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

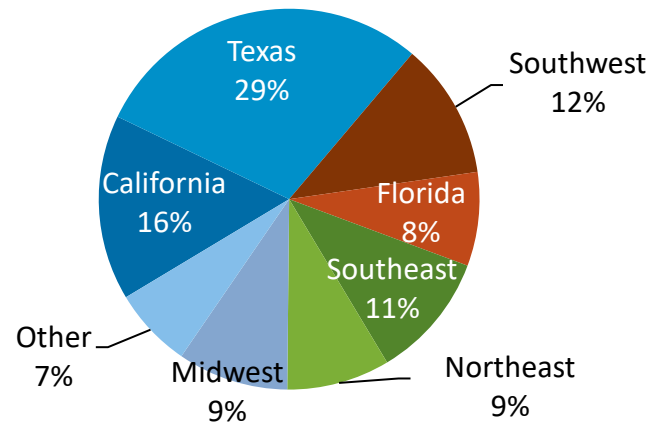
- Wood Mackenzie/SEIA reports a record 21.4  $GW_{dc}$  of PV installations in the first half of 2024—an increase of 54% y/y.
  - The increase came from a doubling of utility-scale installations, which more than made up for the residential market shrinking by one-third.

- Florida, Texas, and California represented 53% of Q1/Q2 installations; however, a total of 10 states installed more than 500 MW<sub>dc</sub> each.
- In Q2 2024, the California residential market shrank to its lowest level since Q2 2020; however, it still represented 20% of national residential installs.
  - Residential installs in 41 states shrank, year over year, in the first half of 2024.

U.S. PV Installations by Market Segment

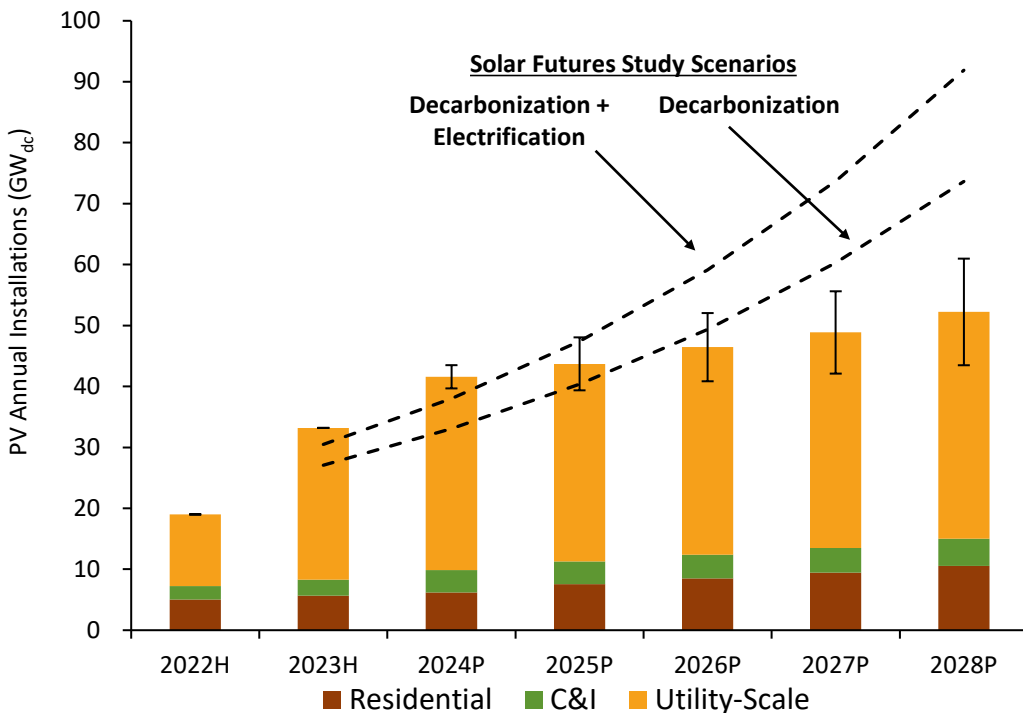


Q1/Q2 2024 U.S. PV Installations by Region (21.4  $GW_{dc}$ )



# Annual U.S. PV Deployment

- About 42 GW<sub>dc</sub> of U.S. PV installations are projected for 2024, up about a quarter from 2023.
- Analysts project continued increases in annual U.S. PV installations:
  - 44 GW<sub>dc</sub> in 2025 (+5% y/y)
  - 46 GW<sub>dc</sub> in 2026 (+6% y/y)
  - 49 GW<sub>dc</sub> in 2027 (+5% y/y)
  - 52 GW<sub>dc</sub> in 2028 (+7% y/y).
- Residential PV has the highest compound annual growth rate over the 2024–2028 period:
  - Utility-scale 4%
  - Commercial and industrial (C&I) 5%
  - Residential 14%.
- In 2028, the median analyst projection falls short of trajectories in DOE’s Solar Futures Study: 20 GW<sub>dc</sub>/y short (Decarbonization scenario), 40 GW<sub>dc</sub>/y short (Decarbonization + Electrification scenario).
- Over the period shown, deployment is geographically diverse, with Texas, California, and Florida as the top states and considerable capacity in multiple regions.

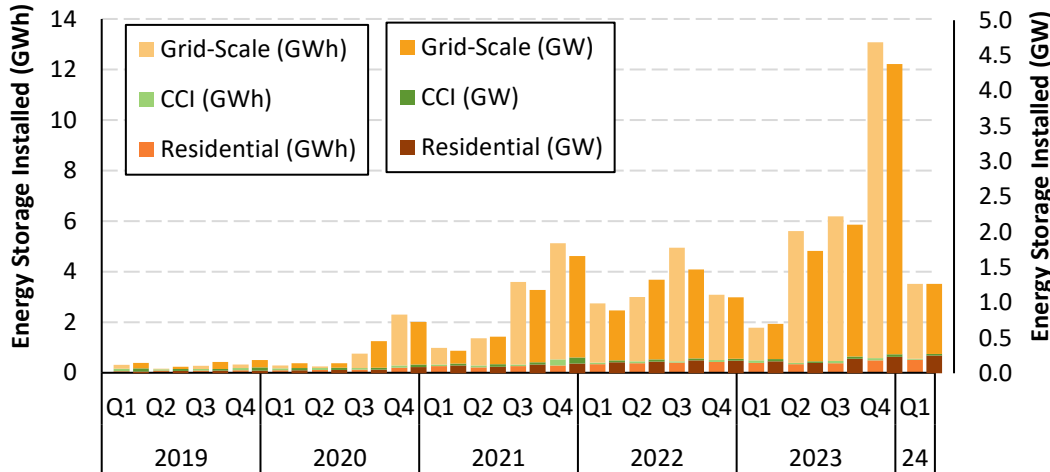


**Notes:** H = historical data; P = projection from analysts. Bars represent historical data (2022–2023) and median U.S. projections (2024–2028). Error bars represent high and low U.S. projections. Where sector medians do not sum to U.S. medians, differences are reconciled by multiplying the median percentage contribution from each sector by the total U.S. median values so the correct total median values are retained. Solar Futures scenarios in GW<sub>ac</sub> are converted to GW<sub>dc</sub> using a DC-to-AC ratio of 1.3. **Sources:** BNEF, 2Q 2024 Global PV Market Outlook, 5/23/24; DOE, [Solar Futures Study](#), 9/21; IEA, [Snapshot of Global PV Markets: 2024](#), 4/24; Wood Mackenzie and SEIA, US Solar Market Insight, Q2 2024, 6/24.

# U.S. Energy Storage Installations by Market Segment

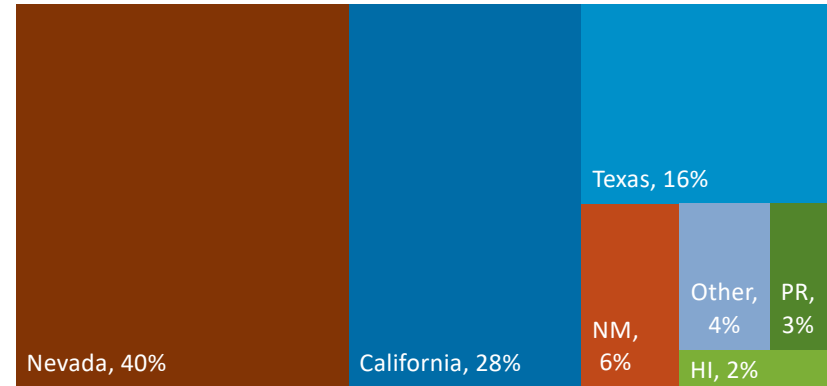
- The United States installed approximately 3.5 GWh (1.3 GW<sub>ac</sub>) of energy storage onto the electric grid in Q1 2024—its largest first quarter on record, though significantly lower than installations in the previous three quarters.
  - Residential and grid-scale installs were up 48% and 101%, respectively, year over year, with 84% of installs located in Nevada, California, and Texas.
  - Residential installs were up 8% q/q—its highest quarter on record—with California driving the growth, representing over half the market (tripling its quarterly installs, year over year).

U.S. Energy Storage Installations by Market Segment



- California residential attachment rates for storage grew from 29% to 46% between Q4 2023 and Q1 2024. More than half of the residential installs were under NEM 3.0 in Q1, compared to 1/3 in Q4. As the shift to NEM 3.0 continues, Wood Mackenzie expects that the attachment rate will continue to grow.
- Wood Mackenzie reports that CCI continues to stagnate as the Massachusetts market faces interconnection delays caused by cluster studies, New York aims to ease fire safety and zoning restrictions, and California’s CPUC adopted compensation scheme for community solar was lower than expected.

Q1 2024 U.S. Energy Storage Installations by Region (3.5 GWh)



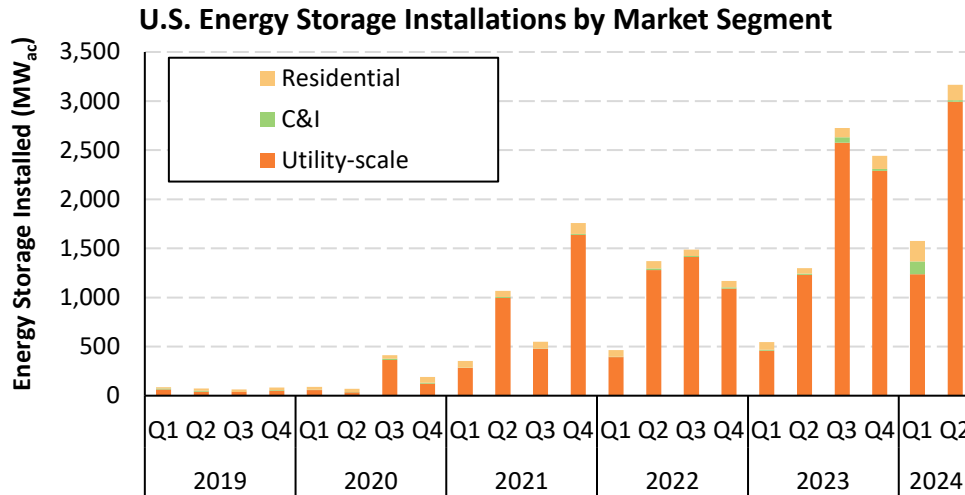
**Note:** “Grid-scale” refers to all projects deployed on the utility side of the meter, regardless of size or ownership; “CCI” refers to community-scale, commercial, and industrial.

HI = Hawaii; NM = New Mexico; PR = Puerto Rico. **Source:** Wood Mackenzie Power & Renewables and Energy Storage Association, [U.S. Energy Storage Monitor: Q2 2024](#).

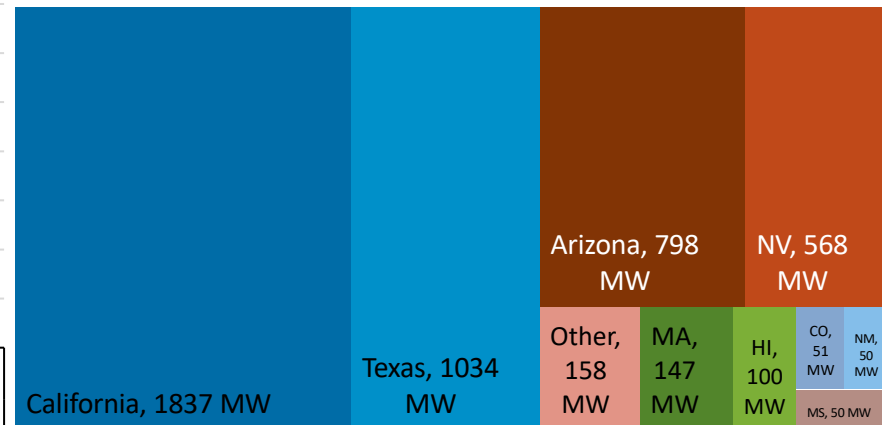
# U.S. Energy Storage Installations by Market Segment (EIA)

- EIA reports that the United States installed approximately 4.8 GW<sub>ac</sub> of energy storage onto the electric grid in the first half of 2024—up 154% y/y.
- Q2 2024 was the highest on record because of high utility-scale BESS installations.

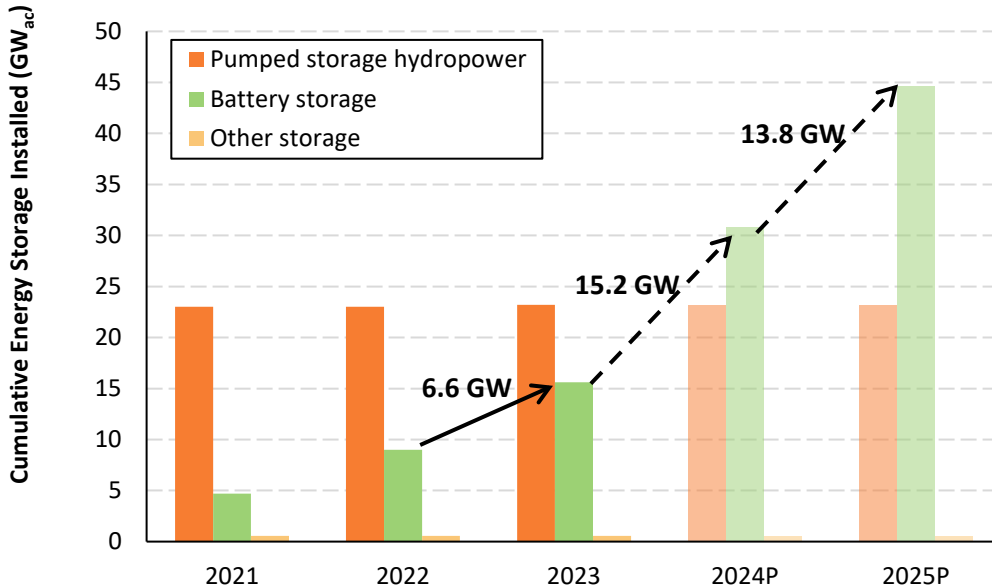
- California represented 38% of battery installations in the first half of 2024, followed by Texas (22%) and Arizona (17%).
- Six states installed more than 100 MW<sub>ac</sub> of storage in the first half of 2024.



**Q1/Q2 2024 U.S. Energy Storage Installations, Region (4.8 GW<sub>ac</sub>)**



# Utility-Scale U.S. Energy Storage Installation Projections (EIA)

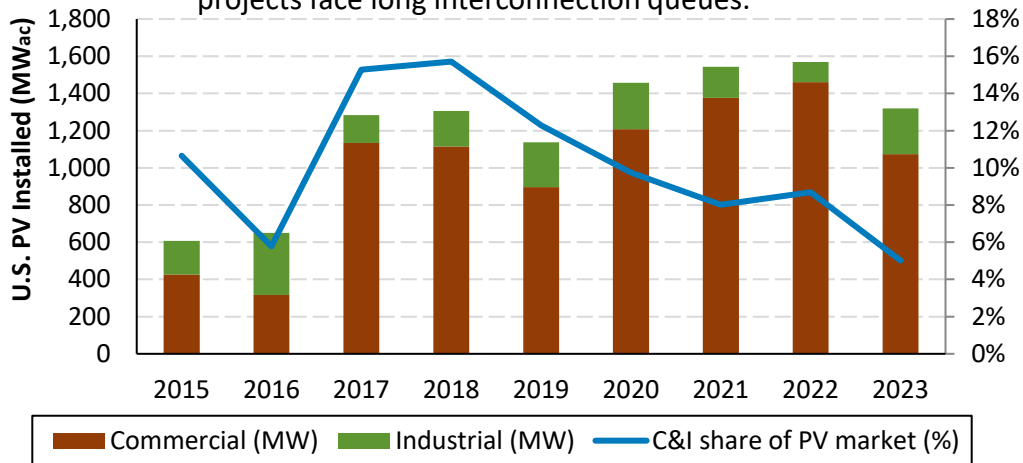


- The Q1/Q2 2024 record-setting level of U.S. battery energy storage installations is in line with EIA’s projections of cumulative utility-scale battery storage capacity, which EIA projects will grow to 30.8 GW<sub>ac</sub> (70 GWh) in 2024 and 44.6 GW<sub>ac</sub> (94 GWh) in 2025.
- EIA projects that, by the end of 2024, battery storage will be the largest source of storage (by gigawatts of capacity) in the country, surpassing pumped storage hydropower.
  - However, DOE estimates that the 23 GW<sub>ac</sub> of pumped storage hydropower has an energy storage capacity of 553 GWh—still far greater than the 70 GWh of battery energy storage capacity projected by the end of 2024.



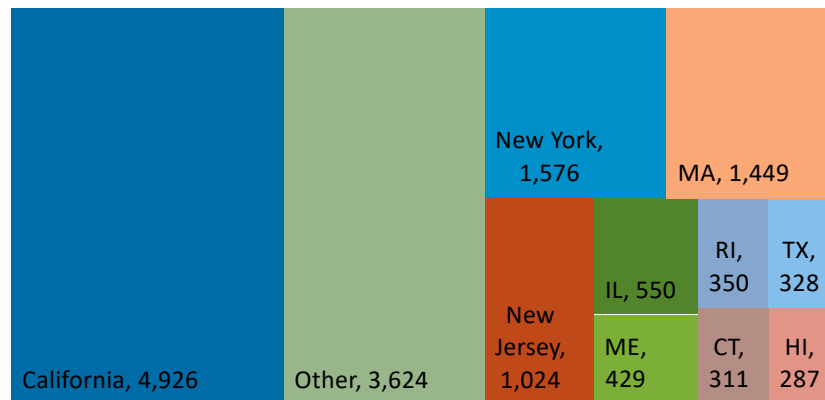
# U.S. Commercial and Industrial PV Markets

- PV installations in the commercial and industrial sectors have been stagnant since 2017, as residential, community solar, and utility-scale PV sectors have grown.
- More than 60% of cumulative capacity has been in four states (CA, NY, MA, NJ).
  - Wood Mackenzie reported that developers are moving into other states as more mature markets get saturated and projects face long interconnection queues.



- Wood Mackenzie reported that 80% of the projects built over the past 5 years were evenly split between projects lower than 500 kW<sub>dc</sub> or above 1 MW<sub>dc</sub>.
  - Approximately half the projects above 1 MW<sub>dc</sub> and one-third of the smaller projects were third-party owned.
- Installers have noted the following key challenges to commercial rooftop development: landlord-tenant alignment; low electric-load buildings (relative to roof size); roof age, condition, and structural capability; and a capital availability and solar payback period relative to a company's time horizon.

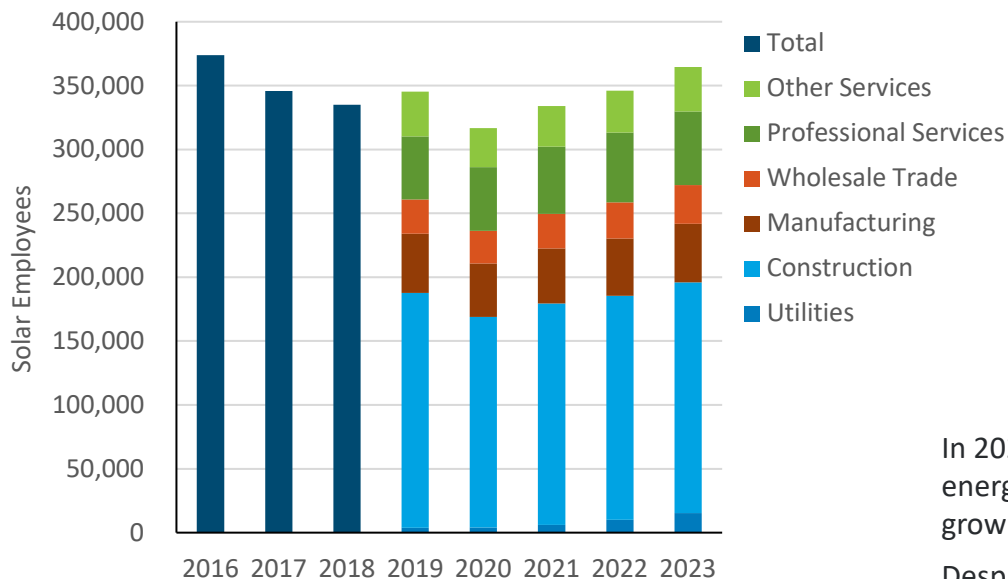
## Cumulative C&I PV Deployment (MW), 2023



# U.S. Solar Workforce (USEER)

This is a growth of 5.3% (18,401) over 2022 and 6% growth over 2019, for the first time growing significantly over pre-pandemic levels.

At the end of 2023, more than 360,000 U.S. employees spent some of their time on solar, mostly in the construction sector.



- A significant portion of that job growth came from the utilities industry (+51%, +5,141 new jobs) and construction (+3%, +5,318 new jobs). The other categories also gained 1,000 to 3,000 workers as well.
- The number of workers represented by unions grew 13.7% (+5,000 jobs). Approximately 14% of the solar workforce is represented by a union, compared to the national workforce average of 7%.
- Female workers are underrepresented within the solar workforce (30% vs. 47% nationally).
- The solar workforce is more racially diverse than the national workforce (27% non-white workers vs. 24% nationally). Veterans and Hispanic/Latino workers continued to be relatively overrepresented, whereas Black or African American workers were underrepresented in 2023.

In 2023, just under 5% of new jobs in the United States were in clean energy. And USEER estimates that in 2024, the solar workforce could grow by 9%.

Despite announcements of jobs losses in California because of the transition of NEM 3.0, USEER reported a slight increase in solar energy jobs in the state, year over year (from 115,00 to 119,000).

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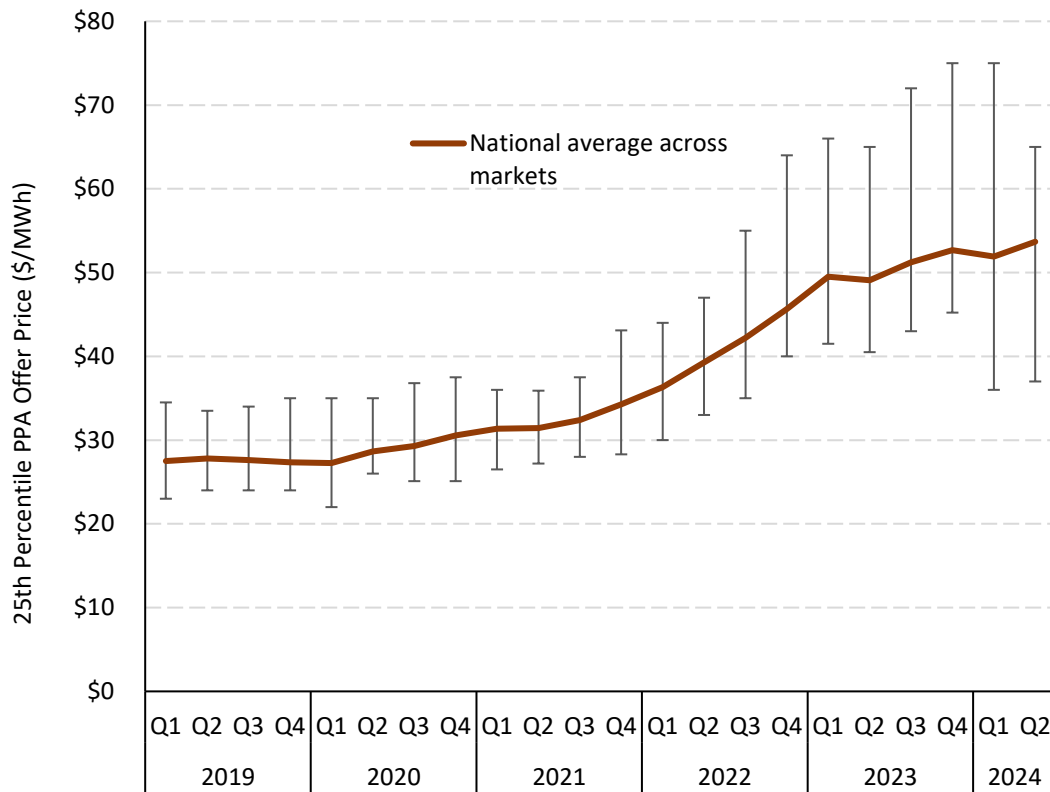
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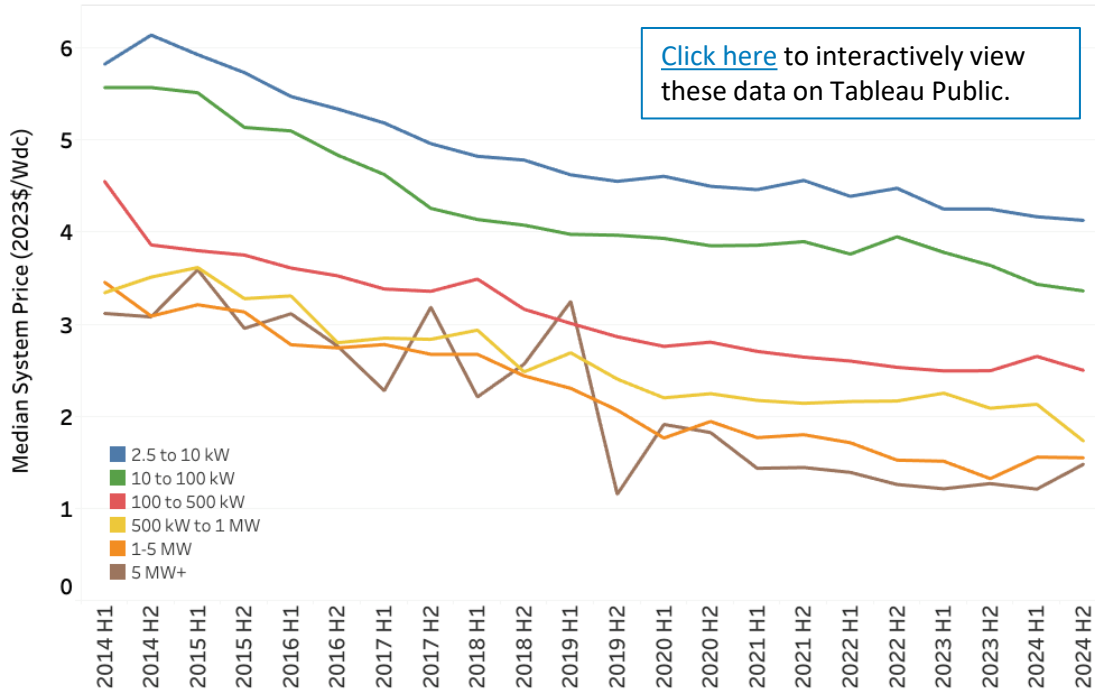
- LevelTen reports the U.S. utility-scale PV PPA prices increased approximately 3% q/q and 9% y/y.
- From the first half of 2023 to the first half of 2024, the inflation-adjusted median reported distributed PV system price across Arizona, California, Massachusetts, and New York:
  - Decreased 2% to \$4.17/W<sub>dc</sub> for systems 2.5 to 10 kW
  - Decreased 8% to \$3.46/W<sub>dc</sub> for systems 10 to 100 kW
  - Increased 4% to \$2.61/W<sub>dc</sub> for systems 100 to 500 kW
  - Decreased 2% to \$2.23/W<sub>dc</sub> for systems 500 kW to 1 MW
  - Increased 4% to \$1.65/W<sub>dc</sub> for systems 1 to 5 MW
  - Decreased 8% to \$1.14/W<sub>dc</sub> for systems 5 MW+.
- In 2024 YTD, residential PV-plus-storage systems in California had a median system price of \$3,160/kWh, or \$5,723/kW<sub>ac</sub> (\$5,518/kW<sub>dc</sub>)—comparable to 2023 prices when adjusted for inflation.

# U.S. Solar PPA Pricing (LevelTen)



- LevelTen reports that the U.S. utility-scale PV PPA prices increased approximately 3% q/q and 9% y/y.
- LevelTen reports that the increase in PPA prices reflects the ongoing challenges developers face of long interconnection queues, permitting delays, and uncertainty over trade duties on solar products.
  - LevelTen also reported changes to PPAs to mitigate some of these risks by indexing PPA pricing to tariffs and interest rates or putting in “conditions precedent,” which would release parties from the contract should “unlikely but untenable adverse events occur during development.”
  - The increase in pricing may also reflect a growing amount of bundled storage with solar; however, LevelTen has not made that attribution.
- LevelTen reported that ERCOT was the lowest-priced market in Q2 2024 because of land availability and easy permitting for solar. PJM continued to be one of the more expensive markets in part because of interconnection challenges. The ISO has reformed its interconnection process recently, and therefore LevelTen reported that the coming quarters could show whether those reforms, which are similar to broader reforms made by FERC, were effective.

# Distributed PV System Pricing From Select States



From H1 2023 to H1 2024, the median reported standalone (no energy storage) distributed PV system price—in **2023 (inflation-adjusted) dollars**—across Arizona, California, Massachusetts, and New York:

- Decreased 2% to \$4.17/W<sub>dc</sub> for systems 2.5 to 10 kW
- Decreased 9% to \$3.43/W<sub>dc</sub> for systems 10 to 100 kW
- Increased 6% to \$2.65/W<sub>dc</sub> for systems 100 to 500 kW
- Decreased 5% to \$2.13/W<sub>dc</sub> for systems 500 kW to 1 MW
- Increased 3% to \$1.56/W<sub>dc</sub> for systems 1 to 5 MW
- Stayed flat at \$1.21/W<sub>dc</sub> for systems 5 MW+.

Adjusting for inflation reveals the generally decreasing distributed PV system price trends in real dollars over the past several years of economic volatility.

**2024 MW data YTD:** Arizona (83), California (356), Massachusetts (17), New York (407).

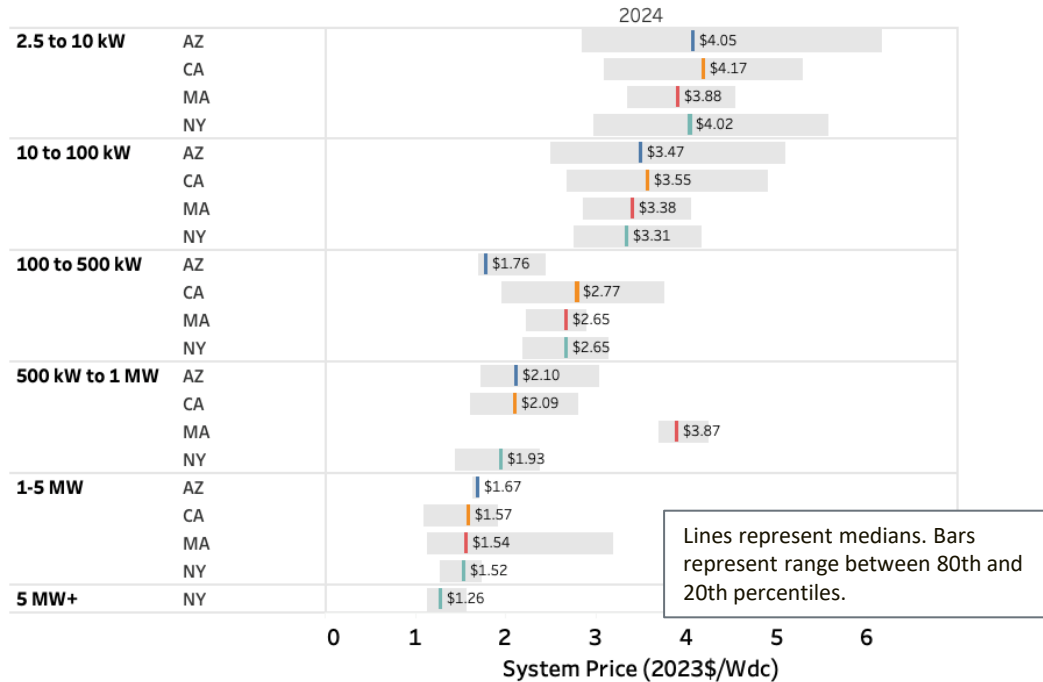
**Note:** System prices above \$10/W and below \$0.75/W were removed from the dataset. The volatility in median system price among the largest systems is due to the relatively small number of systems deployed each year.

**Sources:** [Arizona Goes Solar](#) (8/10/24); [California Distributed Generation](#) (5/31/24); [Massachusetts Lists of Qualified Generation Units](#) (6/7/2024); [Solar Electric Programs Reported by NYSERDA](#) (8/4/24).

# Distributed PV System Pricing From Select States, 2024 YTD

[Click here](#) to interactively view these data on Tableau Public.

Median State Distributed PV Pricing by State



In addition to price differences based on system size, there is variation in the price of stand-alone (no energy storage) distributed PV systems between states and within individual markets.

Dollar-per-watt prices generally decrease as system size increases.

For systems of 2.5 to 10 kW, median price changes varied between 2023 and 2024 YTD:

- 8% in Arizona, -2% in California, -3% in Massachusetts, -7% in New York.

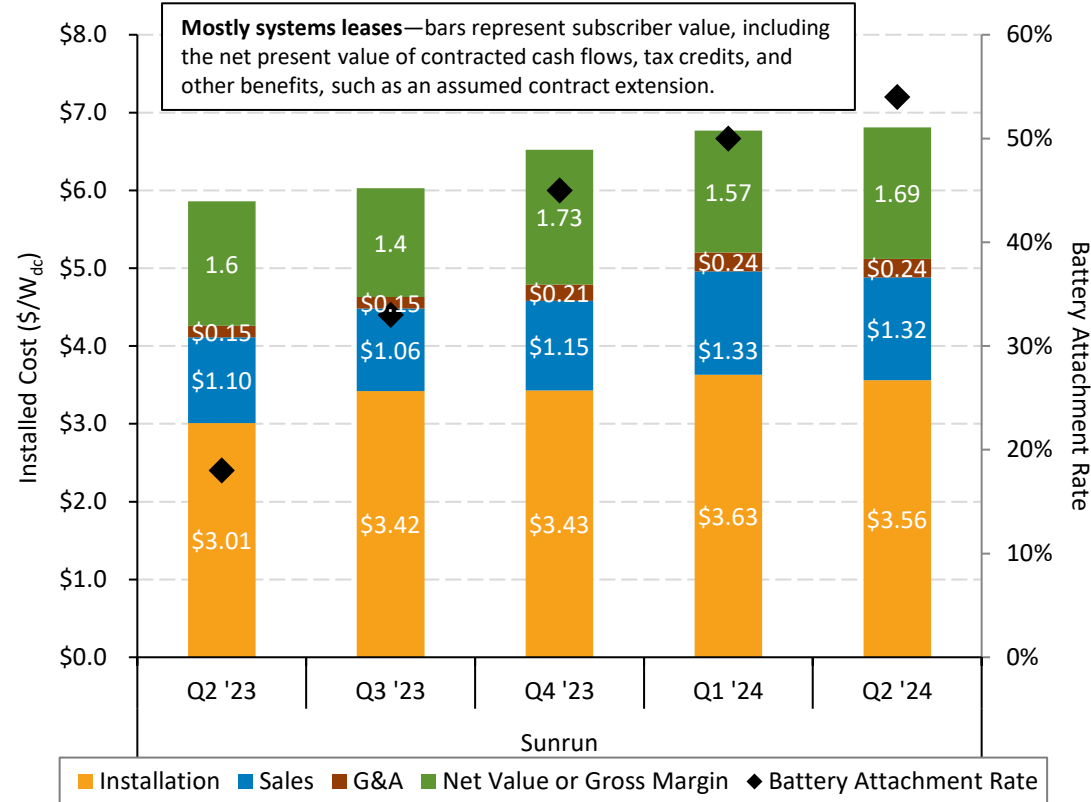
**2024 MW data YTD:** Arizona (83), California (356), Massachusetts (17), New York (407).

**Note:** System prices above \$10/W and below \$0.75/W were removed from the dataset.

**Sources:** [Arizona Goes Solar](#) (8/10/24); [California Distributed Generation](#) (5/31/24); [Massachusetts Lists of Qualified Generation Units](#) (6/7/2024); [Solar Electric Programs Reported by NYSEERDA](#) (8/4/24).

# Large Residential Installer Cost and Value, Q2 2024

Unlike the previous slide, these totals represent value not reported price and may include storage costs.



Large residential installer Sunrun reported a system value change of +16% y/y and +1% q/q in Q2 2024.

Factors reported as supporting higher system value and/or costs (for Sunrun and Sunnova):

- Increasing battery attachment rates (batteries add cost but can yield higher margins)
- Increasing electricity demand and retail rates
- Decreasing reliability of electricity grid
- High interest rates.

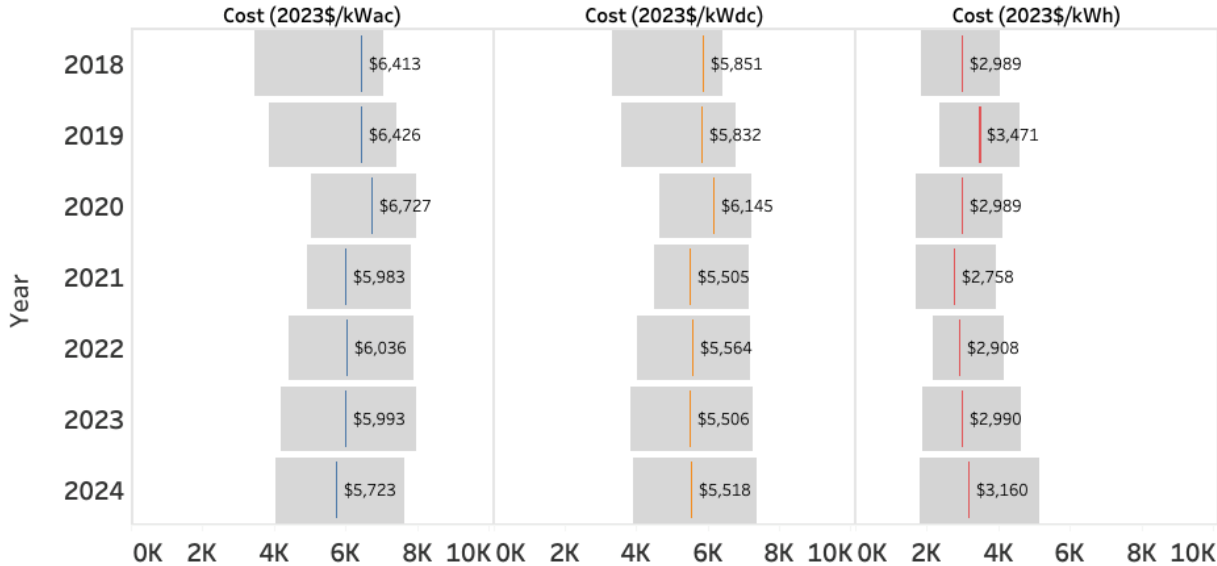
Factors reported as supporting lower PV system costs and/or higher margins:

- Investment Tax Credit adders
- Lower operating expenses.

# Residential PV-Plus-Storage Pricing in California

[Click here](#) to interactively view these data on Tableau Public.

California Residential PV-Plus-Storage Pricing



Lines represent medians. Bars represent range between 80th and 20th percentiles.

- In 2024 YTD, residential PV-plus-storage systems in California had a median system price of \$3,160/kWh, or \$5,723/kW<sub>ac</sub> (\$5,518/kW<sub>dc</sub>)—comparable to 2023 prices when adjusted for inflation.
  - Most of these systems offer 2–3 hours of storage.
  - Units represent total system price divided by the capacity of the battery (kWh) or the capacity of the PV system (kW).

The data are filtered to PV system sizes of 10 kW<sub>dc</sub> or smaller.

Source: [California Distributed Generation](#) (5/31/24).



# Agenda

1 Global Solar Deployment

2 U.S. PV Deployment

3 PV System Pricing

4 **Global Manufacturing**

5 Component Pricing

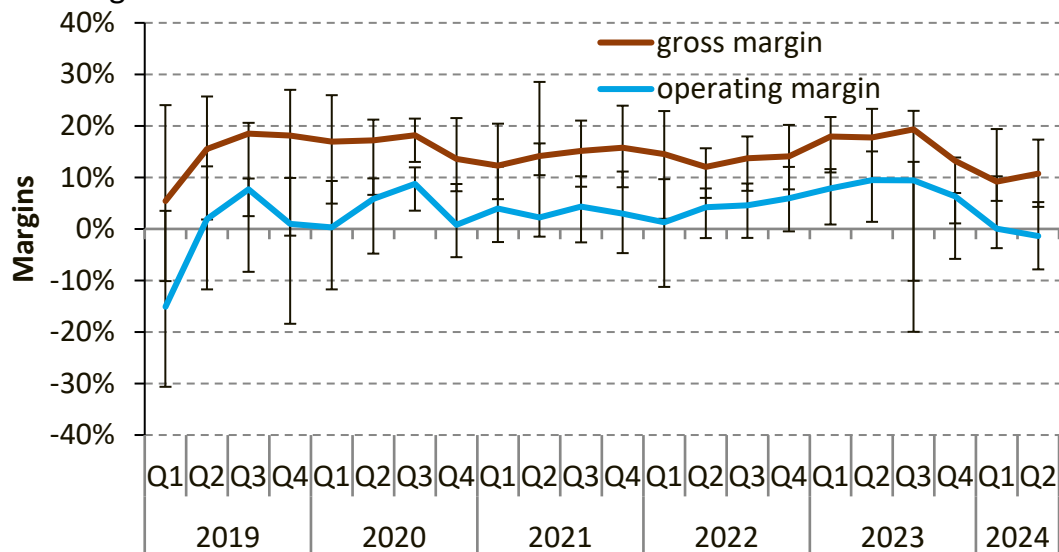
6 Market and Policy

7 U.S. PV Imports

- Despite record levels of module shipments from leading companies, margins from PV manufacturers, on average, remain below historical averages.
- Since the IRA's passage, more than 85 GW of manufacturing capacity have been added across the solar supply chain (from facilities announced pre- and post-IRA) out of 335 GW announced, including nearly 35 GW of new module capacity.

# PV Manufacturers' Margins

Despite record levels of module shipments from leading companies, margins from PV manufacturers, on average, remain below historical averages.



Lines represent the median, with error bars representing 80th and 20th percentiles for the following companies in Q4 2023: Canadian Solar, First Solar, JA Solar, Jinko Solar, LONGi, Moxeon, Motech Industries, REC Silicon, Renesola, Risen, Shanghai Aiko, Shanghai Aerospace, Tongwei, Trina Solar, and United Renewable Energy.

**Note:** Gross margin = revenue minus 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.

- Average operating margin experienced its fourth straight decline, falling into negative territory, and gross margins from 7 of the 10 leading public declined from Q1 to Q2 2024.
- Conversely, First Solar's gross margin increased to levels not seen in over a decade.
  - First Solar estimated that in 2024 it would earn \$2B in gross margin with \$1B from the 45X manufacturing production tax credit.
- R&D and manufacturing also continue to make improvements. Jinko Solar announced that it is producing N-type cells with an efficiency above 26% and would reach 26.5% by the end of 2024 and 27% by 2025. It also announced a new record conversion efficiency of 33.2% for its TOPCon/Perovskite tandem cell.

# Global Supply Chain Manufacturing

- In May 2024, the U.S. Department of Commerce **initiated an antidumping and countervailing duties (AD/CVD) investigation** into PV cell and module imports from **Cambodia, Malaysia, Thailand, and Vietnam**. In 2023, those four countries cumulatively accounted for 79% of U.S. cell and module imports.
- In June 2024, the U.S. International Trade Commission determined that there is **reasonable indication that the U.S. PV manufacturing market is being injured by imports from these four countries**.
- Preliminary countervailing duty values are expected to be published in September, and preliminary antidumping duty values are expected to be published in October.
- In response to new AD/CV duties, the United States could do either of the following:
  - 1) **Continue importing** cells and modules from Cambodia, Malaysia, Thailand, and Vietnam at **higher prices**
  - 2) **Shift where it sources its cells and modules** to reduce reliance on the four tariff-imposed countries.
- If the second scenario ensues, this could impact manufacturing operations in southeast Asia and shift global markets.
- We looked at 2023\* global cell and module import and export data from the International Trade Centre to investigate the flows of cells and modules into and out of countries of interest. For each country, we show cell imports, cell exports, and module exports that make up more than 1% of the country's total imports/exports. Different colors represent the different countries of origin/termination, and the thickness of the lines indicates the size of the import/export flow (in USD).

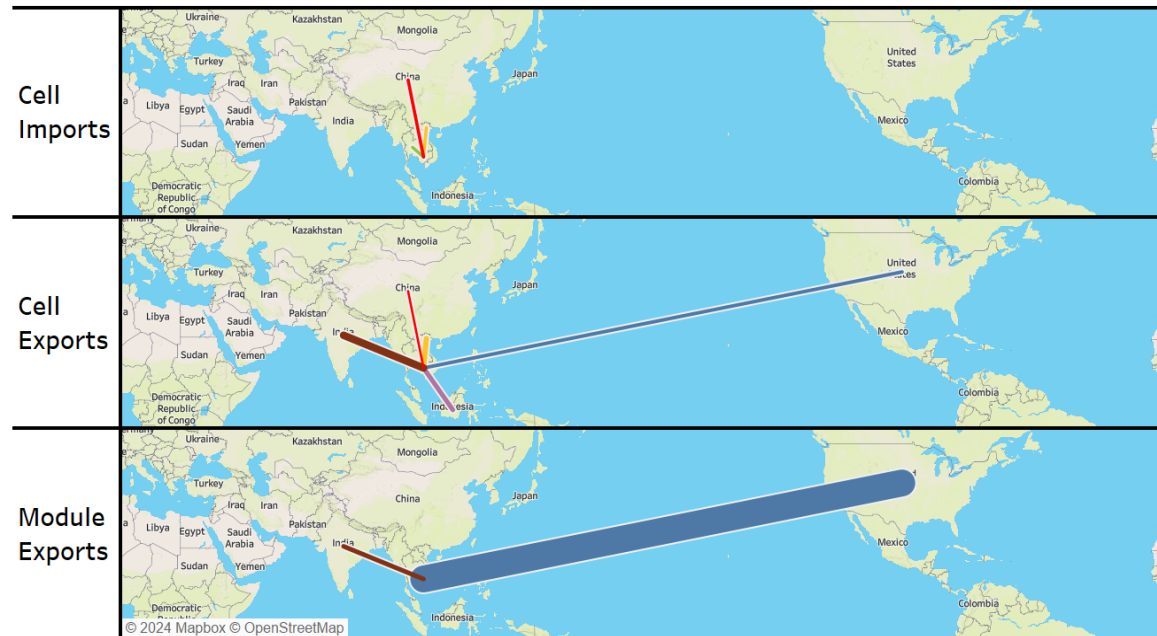
\***Note:** For Vietnam, we used 2022 data as those were the most recent data available.

**Sources:** [Commerce Initiates Antidumping and Countervailing Duty Investigations of Crystalline Silicon Photovoltaic Cells from Cambodia, Malaysia, Thailand, and the Socialist Republic of Vietnam](#), U.S. International Trade Administration, May 15, 2024. [Spring 2024 Solar Industry Update](#), National Renewable Energy Laboratory, May 2024. [USITC Votes to Continue Investigations on Crystalline Silicon Photovoltaic Cells, Whether or Not Assembled into Modules from Cambodia, Malaysia, Thailand, and Vietnam](#), U.S. International Trade Commission, June 7, 2024. [Trade Map—Trade statistics for international business development](#), International Trade Centre, accessed August 2024.

# Global Supply Chain— Cambodia

Cambodia is a relatively small cell and module manufacturer, having produced a little over 4 GW of cells and over 3 GW of modules in 2023. Although they have a somewhat diversified set of buyers for their PV cells, almost all the PV modules they export go to the United States, introducing high risk for this market should the U.S. stop importing from Cambodia.

Cell Imports to and Cell Exports and Module Exports From Cambodia (USD)



- In 2023, Cambodia imported almost **\$45 million USD** of PV cells. 100% of cell imports came from Vietnam, China, and Thailand (each country contributed roughly 1/3 of cell imports).
- In 2023, Cambodia exported over **\$236 million USD** of PV cells, equivalent to roughly 1.4 GW. Almost 50% of cell exports went to India with another almost 49% going to Vietnam, Indonesia, the United States, and China.
- In 2023, Cambodia exported over **\$1.8 billion USD** of PV modules, equivalent to roughly 5.2 GW. More than 97% of module exports went to the United States and around 2% went to India; <1% went to several other countries, including Canada, Pakistan, and China.

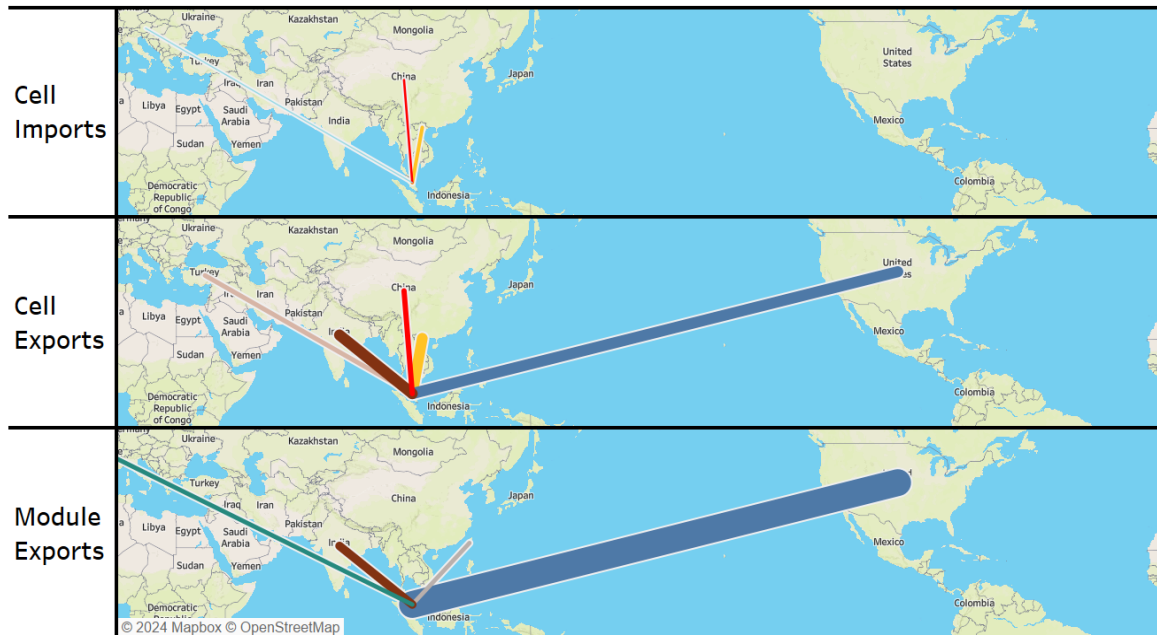
**Sources:** [Trade Map - Trade statistics for international business development](#), International Trade Centre, accessed August 2024. PV Manufacturing & Technology Quarterly Report—Release 32, PVTech Research, February 2024.

**Note:** Conversions from USD to GW were done using country-level \$/W import data from the [U.S. Census Bureau USA Trade Online tool](#) and [corrections](#) page as of 5/6/24.

# Global Supply Chain— Malaysia

Malaysia is a major cell and module manufacturer, having produced more than 14 GW of cells and nearly 12 GW of modules in 2023. Although they have a somewhat diversified set of buyers for their PV cells, a significant number of the PV modules they export go to the U.S., introducing risk for this market should the U.S. stop importing from Malaysia.

Cell Imports to and Cell Exports and Module Exports From Malaysia (USD)



- In 2023, Malaysia imported more than **\$36 million USD** of PV cells. More than 73% of cell imports came from Vietnam, more than 21% came from China, and a little more than 1% came from Austria.
- In 2023, Malaysia exported nearly **\$1.3 billion USD** of PV cells, equivalent to roughly 6.8 GW. Almost 90% of cell exports went to the U.S., India, and Vietnam (each making up about 30% of exports).
- In 2023, Malaysia exported nearly **\$2.9 billion USD** of PV modules, equivalent to roughly 10 GW. More than 87% of modules exports went to the U.S., nearly 8% went to India, and a little more than 1% went to each France and Taiwan; <2% went to several other countries, including Switzerland, Pakistan, and Turkey.

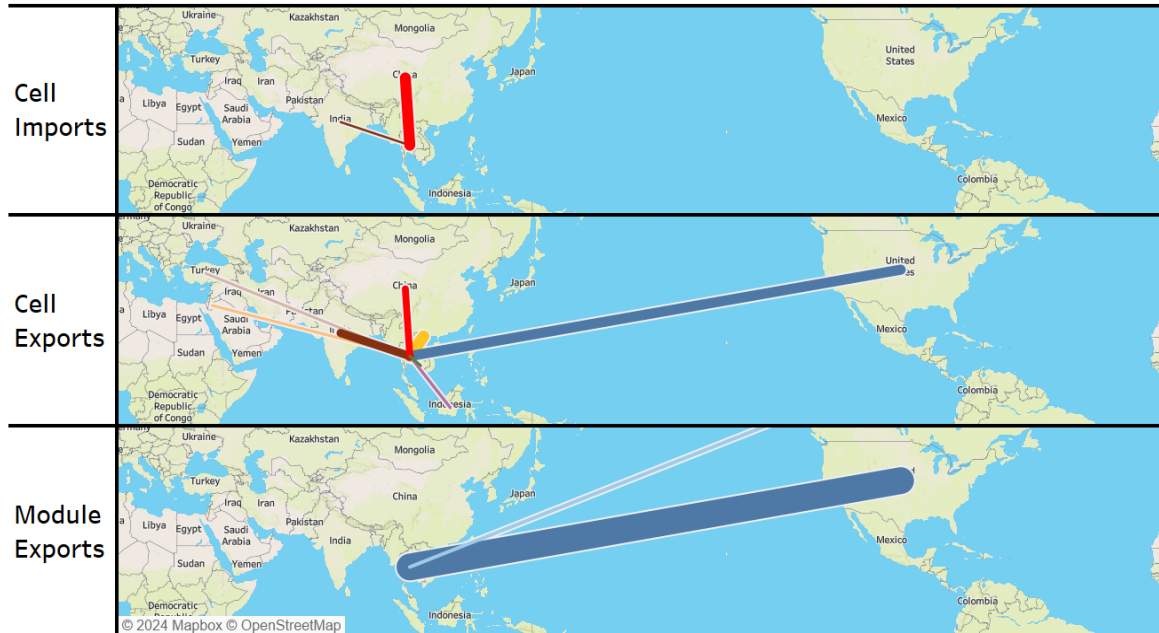
**Sources:** [Trade Map - Trade statistics for international business development](#), International Trade Centre, accessed August 2024. PV Manufacturing & Technology Quarterly Report - Release 32, PVTech Research, February 2024.

**Note:** Conversions from USD to GW were done using country-level \$/W import data from the [U.S. Census Bureau USA Trade Online tool](#) and [corrections](#) page as of 5/6/24.

# Global Supply Chain— Thailand

Thailand is a major cell and module manufacturer, having produced more than 13 GW of cells and more than 8 GW of modules in 2023. Although they have a somewhat diversified set of buyers for their PV cells, almost all the PV modules they export go to the United States, introducing high risk for this market should the U.S. stop importing from Thailand.

Cell Imports to and Cell Exports and Module Exports From Thailand (USD)



- In 2023, Thailand imported over **\$503 million USD** of PV cells. Around 88% of cell imports came from China with another almost 9% being reported as re-import activity and nearly 2% coming from India.
- In 2023, Thailand exported over **\$1.3 billion USD** of PV cells, equivalent to roughly 8.6 GW. Almost 40% of cell exports went to Vietnam, almost 30% went to the United States, almost 20% went to India, and a little more than 10% went to China.
- In 2023, Thailand exported over **\$2.9 billion USD** of PV modules, equivalent to roughly 8.2 GW. More than 97% of exports went to the United States and around 1% of exports went to Canada; <2% went to several other countries, including Taiwan, Pakistan, and China.

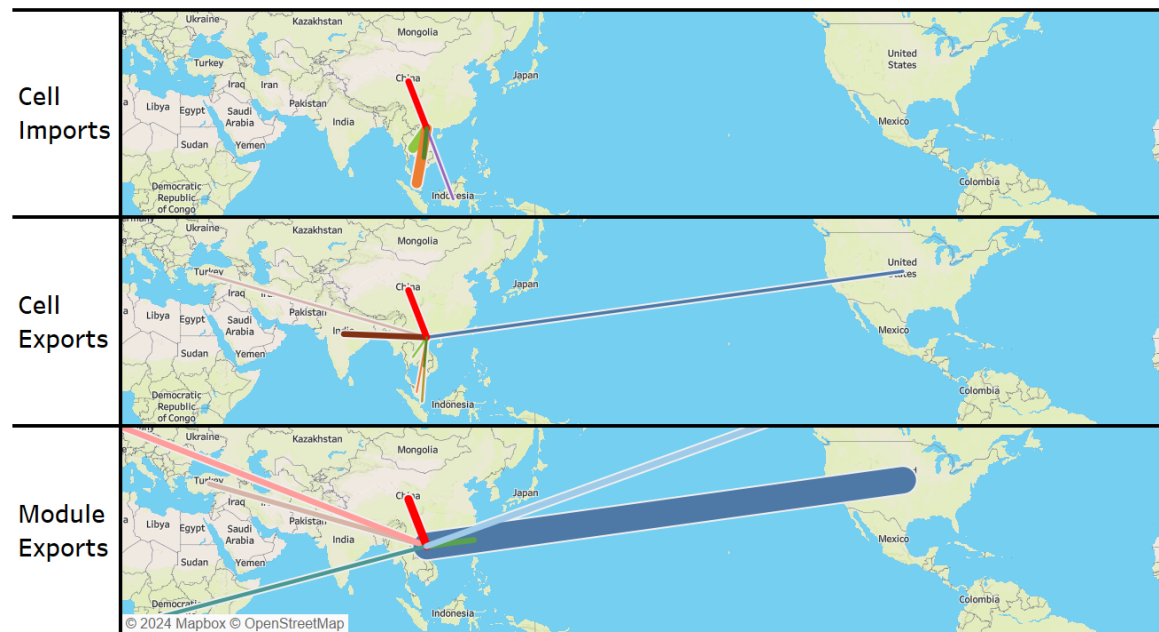
Sources: [Trade Map - Trade statistics for international business development](#), International Trade Centre, accessed August 2024. [PV Manufacturing & Technology Quarterly Report—Release 32](#), PVTech Research, February 2024.

Note: Conversions from USD to GW were done using country-level \$/W import data from the [U.S. Census Bureau USA Trade Online tool](#) and [corrections](#) page as of 5/6/24.

# Global Supply Chain— Vietnam

Vietnam is a major cell and module manufacturer, having produced more than 11 GW of cells and more than 15 GW of modules in 2022. Although they have a somewhat diversified set of buyers for their PV cells and modules, a significant number of their module exports go to the United States, introducing risk for this market should the United States stop importing from Vietnam.

Cell Imports to and Cell Exports and Module Exports From Vietnam (USD)



- In 2022, Vietnam imported over **\$1.5 billion USD** of PV cells. Almost 40% of cell imports came from Malaysia, more than 38% came from Thailand, 14% came from China, 6% came from Cambodia, and around 1% came from Indonesia.
- In 2022, Vietnam exported over **\$541 million USD** of PV cells, equivalent to roughly 2.7 GW. About 43% of exports went to China, 35% went to India, and another 20% went to the U.S., Turkey, Singapore, Cambodia, Thailand, and Malaysia.
- In 2022, Vietnam exported over **\$6.3 billion USD** of PV modules, equivalent to roughly 21 GW. More than 78% of exports went to the U.S., and more than 18% went to China, Canada, Taiwan, Netherlands, Turkey, and Chile.

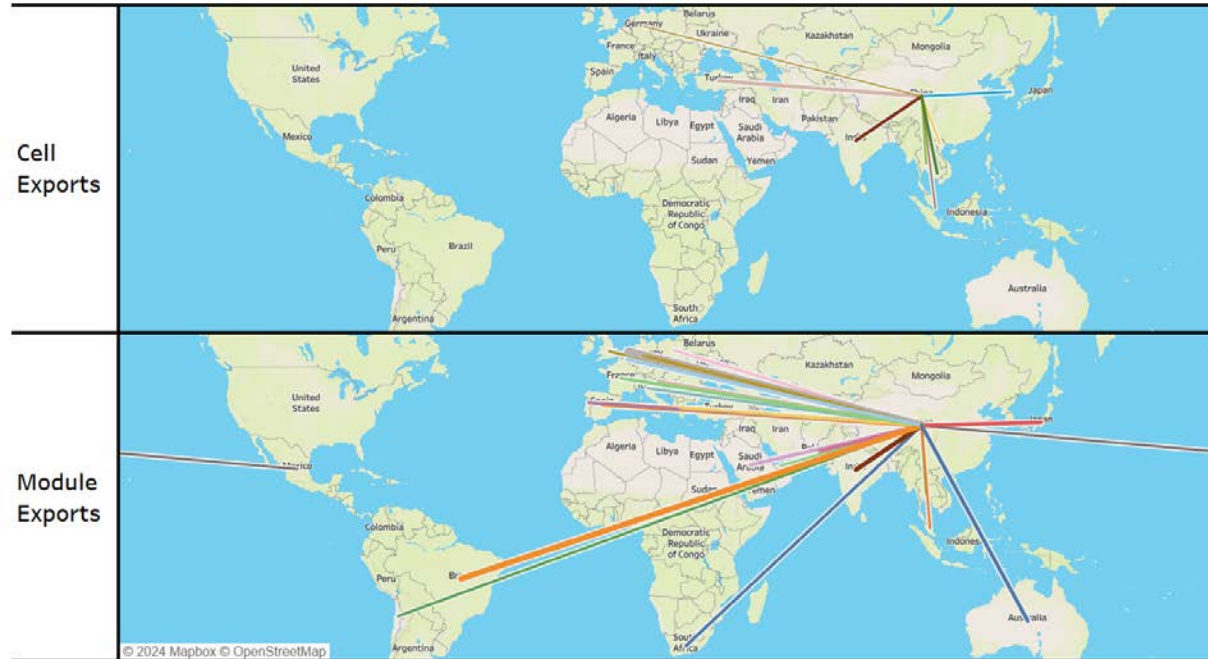
Sources: [Trade Map—Trade statistics for international business development](#), International Trade Centre, accessed August 2024. [PV Manufacturing & Technology Quarterly Report—Release 32](#), PVTech Research, February 2024.

Note: Conversions from USD to GW were done using country-level \$/W import data from the [U.S. Census Bureau USA Trade Online tool](#) and [corrections](#) page as of 5/6/24.

# Global Supply Chain— China

Although the U.S. does not import a significant number of cells or modules from China, they are the world's largest PV cell and module manufacturer, having produced over 463 GW of cells and over 458 GW of modules in 2023. China is also the largest PV exporter. Their market is highly diversified and much less at risk to the impacts of trade actions from a single country than those of the four countries previously explored.

Cell and Module Exports From China (USD)



- In 2023, China exported over **\$4.1 billion USD** of PV cells, equivalent to almost 40 GW. Around 89% of cell exports went to Turkey, India, Cambodia, Thailand, South Korea, Singapore, Vietnam, and Germany (with almost 28% going to Turkey alone). About 4.5% of exports went to the EU-27.
- In 2023, China exported over **\$39.5 billion USD** of PV modules, equivalent to more than 215 GW. More than 84% of module exports went to 24 countries, including the Netherlands, Brazil, Spain, India, Pakistan, Saudi Arabia, Australia, Japan, Belgium, France, Germany, and South Africa. The remaining 16% went to more than 180 other countries. About 48% of exports went to the EU-27.

Sources: [Trade Map—Trade statistics for international business development](#), International Trade Centre, accessed August 2024. [PV Manufacturing & Technology Quarterly Report—Release 32](#), PVTech Research, February 2024.

Note: Conversions from USD to GW were done using 2023 global average cell and module spot prices from the BloombergNEF Solar Supply Chain Index (4/2/24).



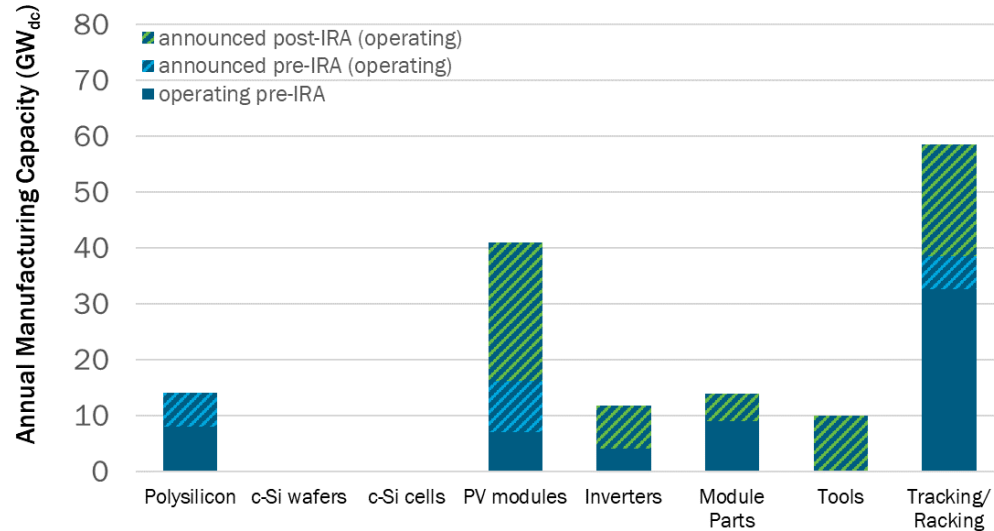
# Global Supply Chain— Key Takeaways

- Although Cambodia, Malaysia, Thailand, and Vietnam have a somewhat more diverse set of cell buyers than module buyers (with the bulk of their offtake in Asia and the U.S.), their module markets are very concentrated. High U.S. offtake for their module manufacturing puts manufacturing operations in these four countries at risk should the U.S. shift imports away from Cambodia, Malaysia, Thailand, and Vietnam.
  - In 2023, almost 8% of Cambodia's total cell exports and over 97% of their module exports went to the U.S.
  - In 2023, over 30% Malaysia's total cell exports and over 87% of their module exports went to the U.S.
  - In 2023, almost 28% of Thailand's total cell exports and over 97% of their module exports went to the U.S.
  - In 2022, over 7% of Vietnam's total cell exports and over 78% of their module exports went to the U.S.
- In contrast, China's market is highly diversified, with their cell and module exports going to many countries across the globe, reducing the risk to their manufacturing operations should a single country (or even a bloc, like the EU-27) take trade action against them.

# Domestic Manufacturing Growth

Since the IRA's passage, over 85 GW of manufacturing capacity has been added across the solar supply chain (from facilities announced pre- and post-IRA), including nearly 35 GW of new module capacity.\*

Manufacturing Capacity by Supply Chain Segment\*



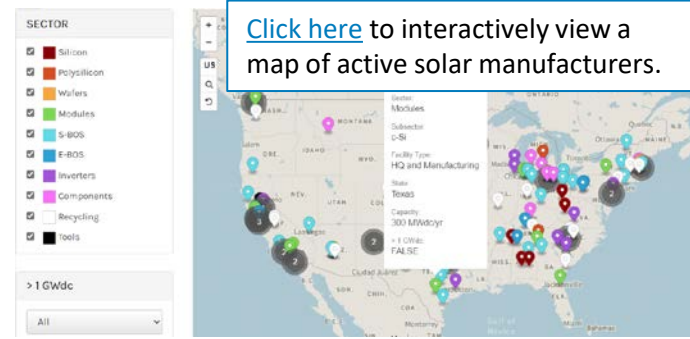
Sources: U.S. Census Bureau USA Trade Online and internal DOE tracking of public announcements.

\*Not all announcements include facility locations, job, operating capacity, or investment numbers.

Several large facilities have hit big milestones in Q1/Q2 2024:

- **Meyer Burger:** Module production in Arizona began in June for their 2-GW facility (though canceled its 2-GW PV cell plant in Colorado).
- **Imperial Star Solar, Elin Energy, and SEG Solar:** Module production in Texas began for their 2-GW facilities in June, March, and August, respectively.
- **Mission Solar and Jinko Solar:** Module manufacturing expansions became operational, bringing them to 1 GW and 2 GW, respectively.
- **Illuminate USA (LONGi/Invenergy):** The 5-GW nameplate facility hit its 1,000,000th panel (~550 MW) and 1,000th employee.

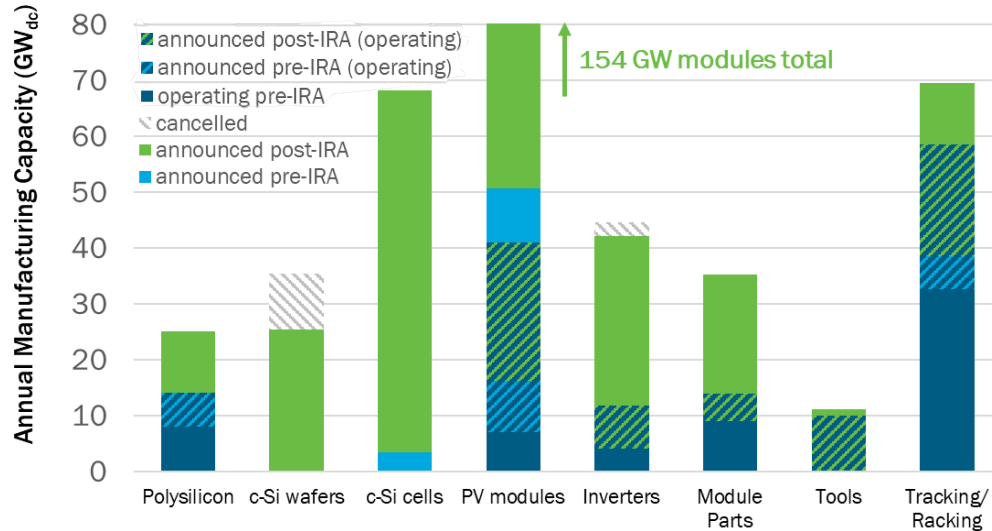
As exemplified by Illuminate's progress announcement, although there are now over 40 GW of nameplate production domestically, manufacturers are still ramping up their capacity.



# Domestic Manufacturing Announcements

Since the IRA's passage, more than 335 GW of manufacturing capacity have been announced across the solar supply chain, representing nearly 33,000 potential jobs and nearly \$17 billion in announced investments across 118 new facilities or expansions.\*

Manufacturing Announcements by Supply Chain Segment\*



Sources: U.S. Census Bureau USA Trade Online and internal DOE tracking of public announcements.

\*Not all announcements include facility locations, job, operating capacity, or investment numbers.

Despite the headwinds noted by these companies (including surging construction costs, high energy prices, and collapsing solar component costs), recent announcements continue to span the different supply chain steps, including:

- PV modules: SEG Solar in TX (+3 GW to a 2-GW facility), Hounen in SC (+2 GW to a 1-GW facility), Solarix in VA (1–3 GW), Astronergy (2 GW)
- PV modules+cells: Recreate (Recom/Create Energy, 5 GW) in TN
- PV cells: Heliene and Premier Energy (1 GW), Ebon Solar in NM, Trina Solar (5 GW)
- Wafer: NorSun confirmed their facility will be in OK and signed an offtake agreement with Heliene
- Polysilicon: NavajoPoly in NM
- Inverters: SolarEdge in FL
- Trackers/Racking: Unimacts in NV, BCI Steel in PA continues to expand, and K2 Systems
- Recycling: Comstock Metals in NV.

Cell manufacturing announcements, in particular, saw significant growth since the last update.

[Click here](#) to interactively view a map of manufacturing announcements.

# Agenda

## 1 Global Solar Deployment

## 2 U.S. PV Deployment

## 3 PV System Pricing

## 4 Global Manufacturing

## 5 **Component Pricing**

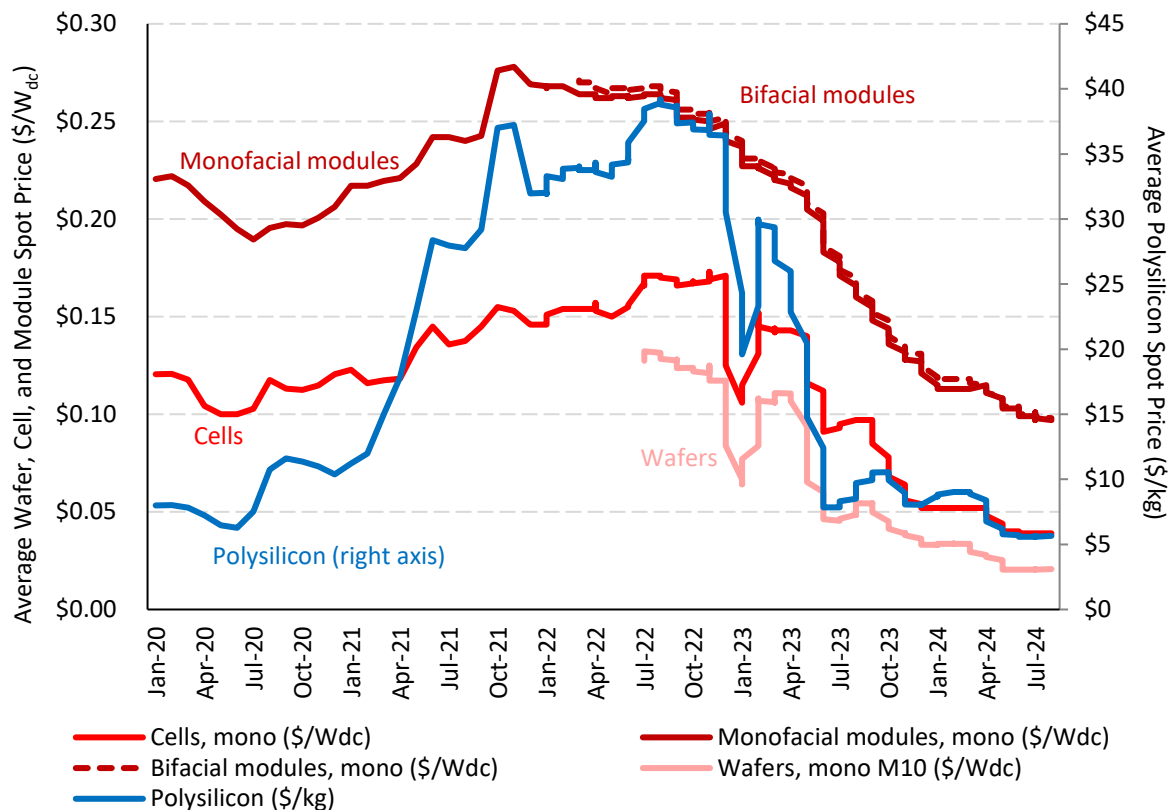
## 6 Market and Policy

## 7 U.S. PV Imports

- In Q3 2024, module prices dropped another 10%, reaching  $\$0.10/W_{dc}$ , with some module prices falling below production costs.
- Global polysilicon spot prices fell 10% from early May ( $\$6.20/kg$ ) to late July ( $\$5.58/kg$ ), the lowest price over the past decade, before increasing 1% ( $\$5.66/kg$ ) in early August. During the same period, global prices decreased for wafers (18%) and cells (11%).
- In Q1 2024, the average U.S. module price ( $\$0.33/W_{dc}$ ) was up 5% q/q and down 8% y/y—a 200% premium over the global spot price for monofacial monocrystalline silicon modules.
- In Q2 2024, the average imported PV cell price was  $\$0.15/W$ .

# PV Value Chain Global Spot Pricing

Global polysilicon spot prices fell 10% from early May (\$6.20/kg) to late July (\$5.58/kg), the lowest price over the past decade, before increasing 1% (\$5.66/kg) in early August.



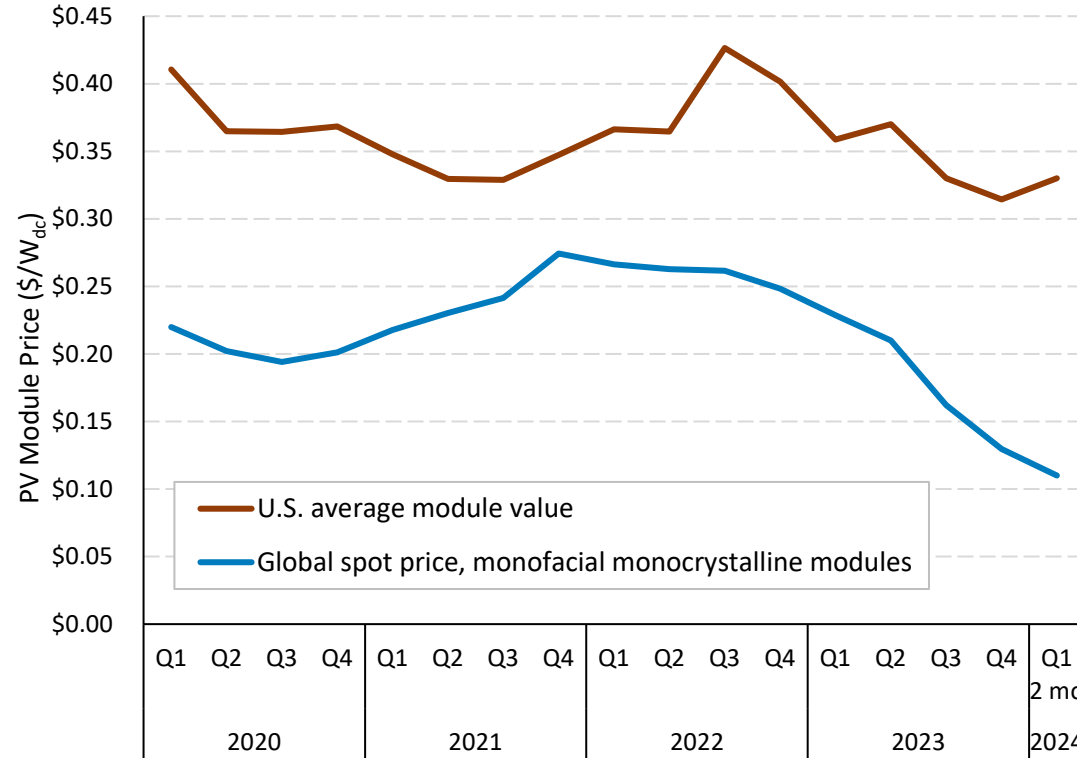
- Oversupply reportedly sent prices below the production costs of all manufacturers, who responded by suspending production, developing differentiated products, or operating at full capacity to reduce costs.
- Prices stabilized and rebounded slightly because of polysilicon production cuts and stockpiling by downstream companies who perceived the bottom of the price cycle had been reached.
- A large industrywide polysilicon inventory suggests prices will remain low in the near term.

During the same period, global prices decreased for wafers (18%) and cells (11%).

Module prices dropped another 10%, reaching \$0.10/W<sub>dc</sub>.

- Some module prices have fallen below production costs, but increased demand in the second half of the year may stabilize prices.

# Module Prices—Global Versus United States



In Q1 2024 (Jan. and Feb.), the average U.S. module price ( $\$0.33/W_{dc}$ ) was up 5% q/q and down 8% y/y, and at a 200% premium over the global spot price.

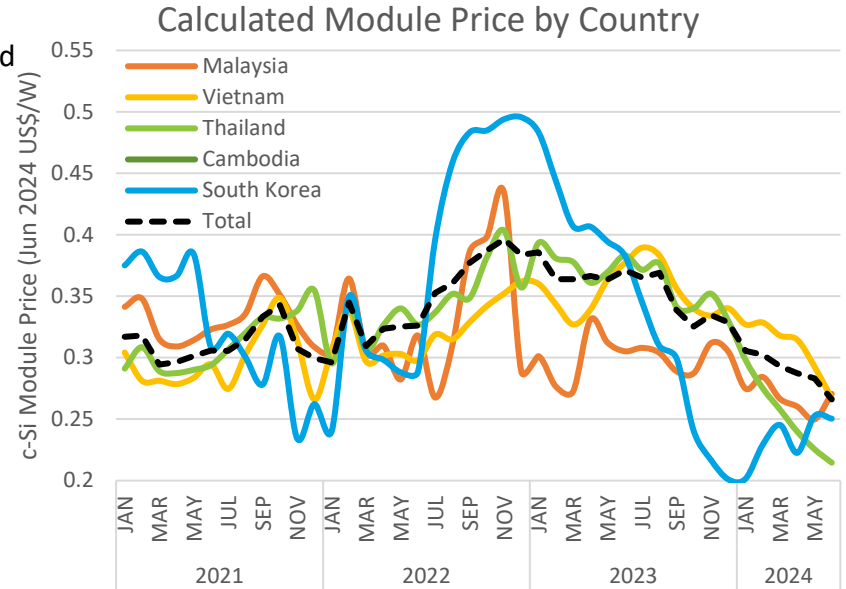
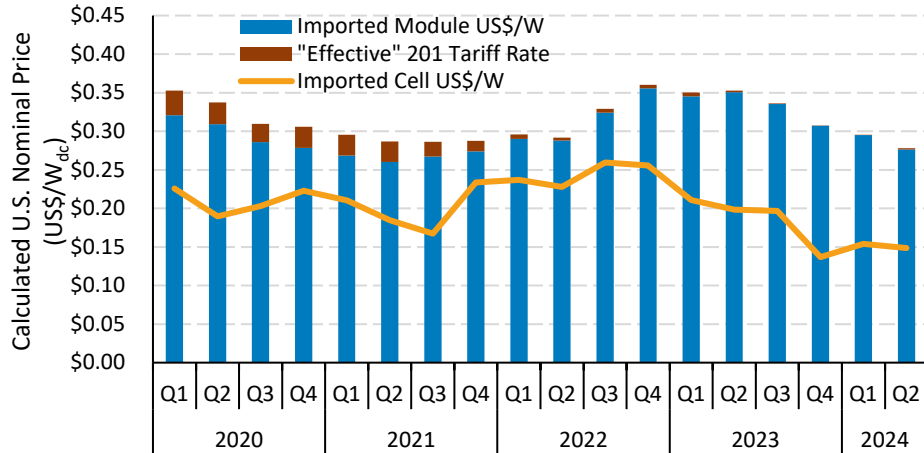
The price difference between U.S. modules and global modules continued to increase, reaching  $\$0.22/W_{dc}$  in Q1.

- The dramatic global module price decline in 2023 continued into 2024 as the U.S. price ticked upward.
- The world-leading module price premium in the U.S. has been maintained by tariffs on Chinese modules as well as module detention under the Uyghur Forced Labor Prevention Act (UFLPA).
- In Q2 2024, the new antidumping and countervailing duty (AD/CVD) investigation on Southeast Asian module imports and the reinstatement of bifacial import duties may have pushed U.S. module prices up further.

# Calculated U.S. Module and Cell Import Pricing

- Based on the reported value and capacity of imported PV modules and cells, in Q2 2024, the average price of the U.S. module fell further to  $\$0.28/W_{dc}$ , while cell prices held steady at  $\$0.15/W_{dc}$ .
  - In Q2, approximately 3% of modules reported paying a tariff, compared to less than 1% in the previous two quarters.

- These module price declines were observed across all countries of import. However, prices declined most steeply over the past several months for modules from Thailand. Current prices are now hitting all-time domestic lows, when adjusted for inflation.



**Note:** The tariff rate was adjusted by the capacity subject to the tariffs. Manual corrections were made to three values because of suspected data entry errors for HTS code 8541430010: Cambodia (February 2022), Malaysia (June 2020), and Vietnam (July 2019). Several gigawatts of imports from India entered under the HTS code for thin-film modules in 2022 to 2024 but are believed to be c-Si based on [news reports](#).

**Sources:** Imports by HTS code: 8541406015(2018-2021)/8541430010(2022-), 8541406035(2018-2021)/8541430080(2022-), and 8541406025(2018-2021)/8541420010(2022-) Second Quantity (watts) from the U.S. Census Bureau [USA Trade Online tool](#) and [corrections page](#) as of 8/6/24.

# Agenda

1 Global Solar Deployment

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2 U.S. PV Deployment

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3 PV System Pricing

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4 Global Manufacturing

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5 Component Pricing

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6 **Market and Policy**

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7 U.S. PV Imports

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- The Invesco Solar ETF fell 11% in Q2 2024, a slower decline than the 18% fall in Q1. For comparison, the S&P 500 rose 4% and the Russell 2000 fell 3% in Q2.
- Virginia passed a law that will allow rooftop solar leasing with a third party.
- Instead of gathering proprietary cost data from manufacturers to claim the 10% domestic content bonus federal tax credit, businesses can now elect to use a safe harbor table, which provides cost percentage information for manufactured product components.



# Domestic Content Bonus 2024 Guidance

In May 2024, the IRS released a safe harbor table that provides clean energy developers an option of relying on DOE-provided default, exhaustive cost percentages in lieu of obtaining direct costs information from suppliers.

The PV table, has columns for ground-mounted (tracker or fixed) and rooftop (which use either MLPE or string inverters) and separates PV modules, racking, and inverters into their components.

	Manufactured Product Component	% for Ground-Mounted (tracking)	
 <p>1) Module</p> 	Cells	36.9	✗
	Frames/backrail	5.3	✓
	Front glass	3.7	✓
	Encapsulant	2.2	✓
	Backsheet/backglass	3.7	✓
	Junction box	1.6	✓
	Edge seals	0.2	✓
	Pottants	0.2	✓
	Adhesives	0.2	✓
	Bus ribbons	0.4	✓
	Bypass diodes	0.4	✓
	<b>Production</b>	11.5	✗

*Project owners add the percentages of the domestically-produced components together to get a total domestic cost percentage.*

**= 17.9%**

*The production line can only be counted if all the components of a product are also domestic.*

Example:



1) Module





2) Tracker



3) Inverter

# Domestic Content Bonus 2024 Guidance

In this example, all the components of the PV tracker are domestically produced and the tracker is made in the United States, so the project owner can count all the percentage values for the tracker—or 24.7%.

 <span style="background-color: #008080; color: white; padding: 2px;">2) Tracker</span> 	Manufactured Product Component	% for Ground-Mounted (tracking)	
	Torque tube	9.7	✓
	Fasteners	0.4	✓
	Slew drive	2.0	✓
	Dampers	0.4	✓
	Motor	3.1	✓
	Controller	0.9	✓
	Rails	2.0	✓
	<b>Production</b>	6.2	✓

= 24.7%

Example:




1) Module






2) Tracker




3) Inverter


# Domestic Content Bonus 2024 Guidance

In this example, the inverter is produced in China, the tracker and most of the PV module components are produced in the United States. Adding the percentages together, the project has a domestic cost percentage of 42.6%, which exceeds the required 40% for a project to receive the bonus credit. Therefore, the project qualifies for the credit.

 <b>3) Inverter</b> 	<b>Manufactured Product Component</b>	<b>% for Ground-Mounted (tracking)</b>	
	Printer circuit board assemblies	36.9	
	Electrical parts	5.3	
	Climate control	3.7	
	Enclosure	2.2	
	<b>Production</b>	11.5	

= 0.0%

$$\text{Domestic Cost Percentage} = 17.9\% + 0.0\% + 24.7\% = \mathbf{42.6\%}$$



Example:



**1) Module**



**2) Tracker**



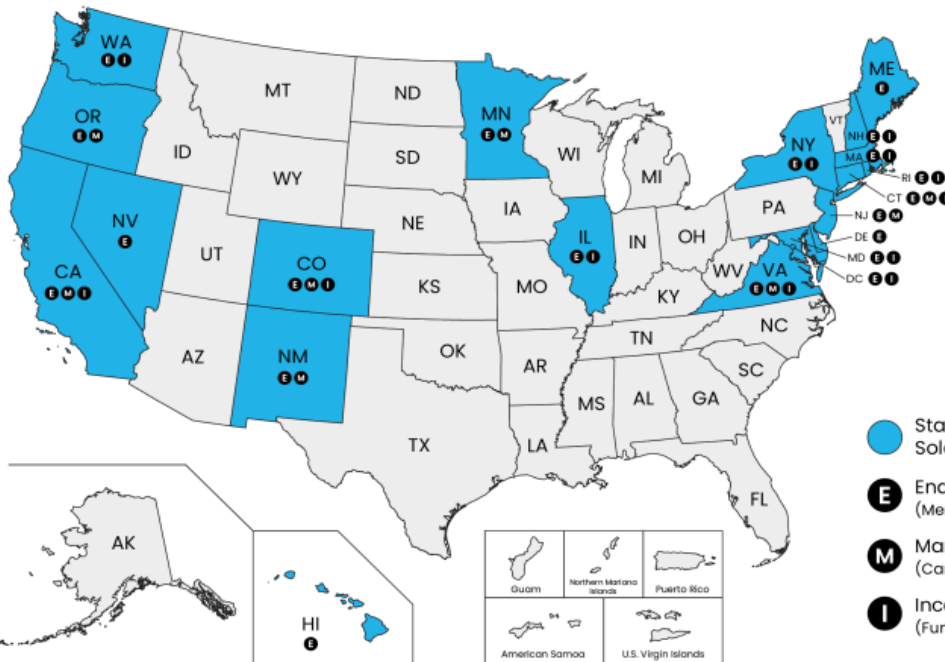
**3) Inverter**

# States: Q2 2024 Updates

**Maryland** passed the Brighter Tomorrow Act into law, which will facilitate the adoption of SolarAPP+ (an automated permitting software) and create a residential solar grant program that allows low- and middle-income households to receive as much as \$7500 in assistance for solar adoption.

**Colorado** passed a law that will optimize its distribution grid for clean energy and decrease interconnection wait times. Colorado also enacted legislation that requires at least 51% of a community solar facility's subscriptions to be reserved for income-qualified customers and allows excess credits to be donated to income-qualified customers.

**Alaska's** state legislature passed a bill requiring Commission-regulated utilities to offer community energy programs.



## States With LMI Incentives or Carve-outs

**Virginia** passed a law that will allow rooftop solar leasing with a third party. They also expanded Dominion Energy's community solar program from 200 to 350 MW and established a framework for a community solar program in the Appalachian Power Company's service area.

**New Mexico** passed a law creating a state tax credit of up to 20% of the costs of the equipment needed to manufacture parts that qualify for the federal Advanced Manufacturing Production Tax Credit (45X).

**Sources:** [Maryland General Assembly passes bill to incentivize local solar development, streamline permitting](#), Solar Power World, 4/10/24. [Community solar legislation awaits governor's signature in Alaska](#), Solar Power World, 5/16/24. [The 50 States of Solar: Q2 2024 Quarterly Report](#), NC Clean Energy Technology Center, 07/2024. [Six Months into 2024, Here are the Year's Biggest State Policy Wins for Solar and Storage](#), SEIA, 7/24/24. [Gov. Michelle Lujan Grisham Signs New Advanced Energy Tax Credit Into Law—New Mexico Partnership](#), New Mexico Partnership, 3/7/24.

Map reproduced from: [Community Solar Market Trends](#), Department of Energy, accessed July 2024.



# Consumer Protection News

In July 2024, the Solar Energy Industries Association (SEIA) [released](#) two new American National Standards Institute-accredited standards for public comment. The standards aim to give customers confidence that they are receiving clear guidance from salespeople and that they receive quality solar and storage installations.

- [Standard 401](#) outlines annual training requirements for solar salespeople. Training programs can vary, but they must cover several basic core competencies to meet this standard, including how to answer common customer questions (related to system design, relevant laws, financial incentives, etc.) and how to accurately provide personalized savings estimates. This standard also outlines the components that companies must include in their purchase agreements, lease agreements, PPAs, and community solar agreements.
- [Standard 201](#) sets a new baseline for how distributed solar and storage systems are installed, including information on fire safety, distribution grid connections, and various environmental conditions. The standard also lists requirements for the quality and expected lifetimes of the modules, inverters, and batteries used in installations and includes a sample inspection checklist.

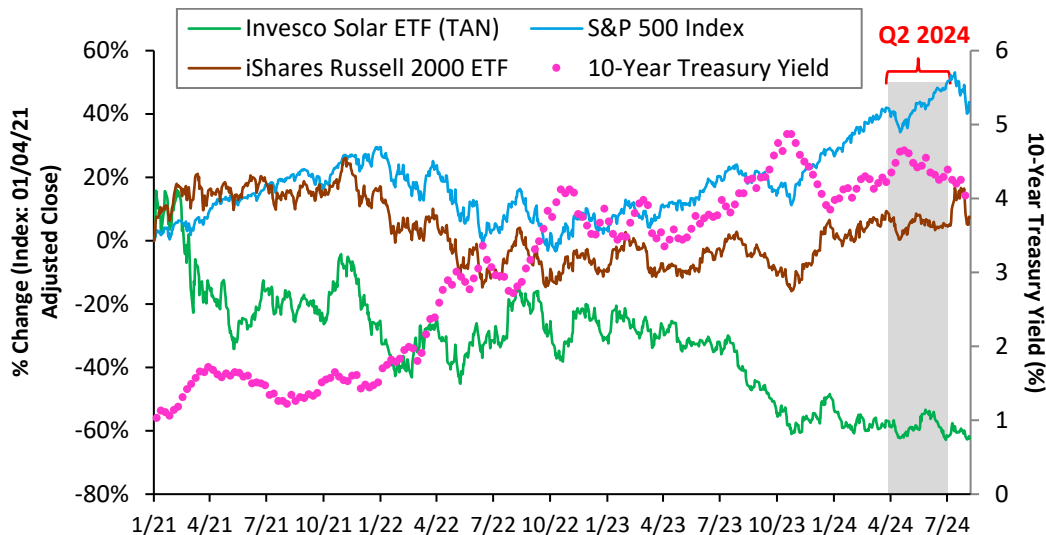
Additionally, in June, a new registry called [Recheck](#) was launched in partnership with SEIA. It allows companies to share information about misconduct, limit the damage done by bad actors, and allows contractors, financiers, and technology platforms to ensure their partners meet standards. Recheck and SEIA will work together to drive adoption of “Recheck IDs” and SEIA’s new standards.

**Finally, in August, the U.S Department of Treasury, Consumer Financial Protection Bureau (CFPB), and the Federal Trade Commission (FTC) [released Consumer Advisories](#), warning the public about how to spot deceptive and unfair practices in the residential solar sector and how to report suspicious behavior to the FTC, the CFPB, and state consumer protection offices.**

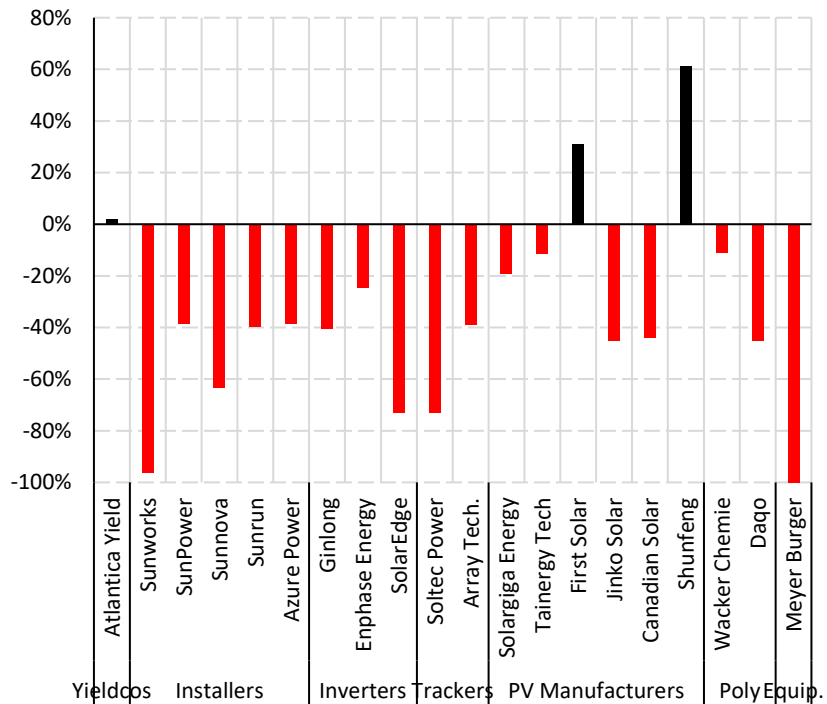
- Treasury, the CFPB, and the FTC also announced an interagency partnership with the U.S. Department of Energy and the U.S. Department of Housing and Urban Development to coordinate efforts and prevent predatory practices in the residential solar space.

# Stock Market Activity

The Invesco Solar ETF fell 11% in Q2 2024, a slower decline than the 18% fall in Q1. For comparison, the S&P 500 rose 4% and the Russell 2000 fell 3% in Q2. Trends in U.S. inflation during the quarter suggested that Federal Reserve interest rate cuts may begin in September, which should boost many solar stocks by reducing borrowing costs for solar projects. Solar projects are particularly sensitive to interest rates because of their high upfront costs. However, concerns over increasing module prices and retroactive duties on imported modules are weighing on stocks related to utility-scale PV projects.



## Individual Stock Performance (Q1-Q2 2024)

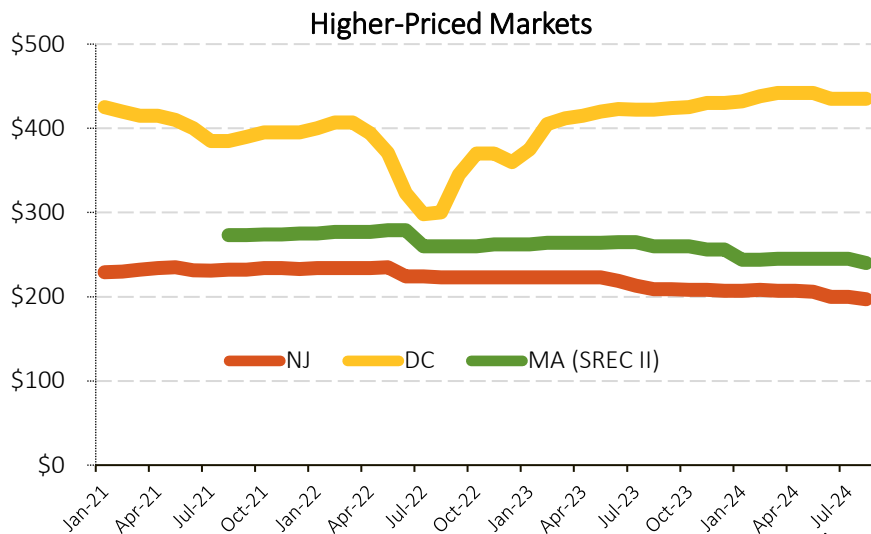
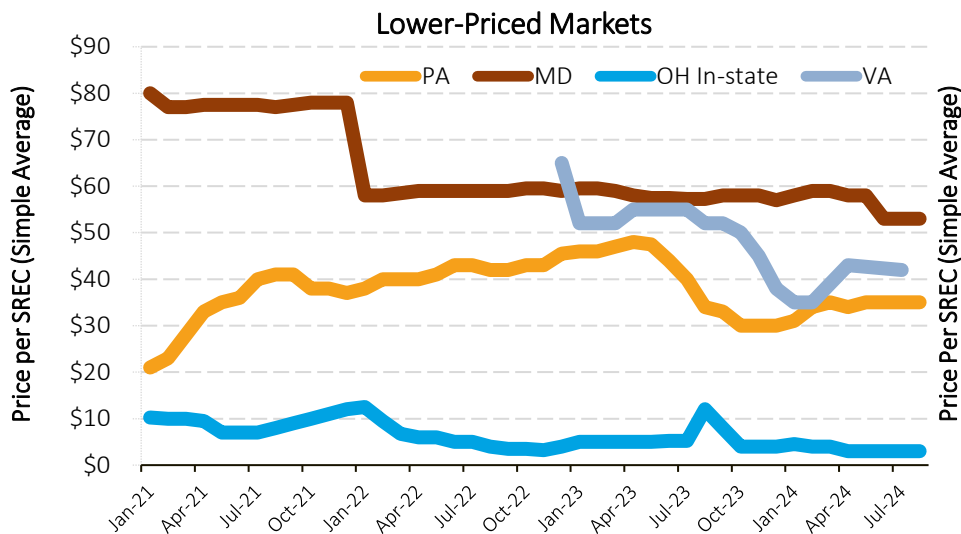


**Note:** The TAN index is weighted toward particular countries and sectors. As of 8/9/24, 50% of its funds were in U.S. companies and 17% were in Chinese companies. Its top 10 holdings, representing 58% of its value, were Enphase, First Solar, Sunrun, Nextracker, GCL, Xinyi, Encavis, HA Sustainable Infrastructure Capital, Neoen, and Clearway Energy.

**Sources:** Federal Reserve Bank of St. Louis ([accessed 8/9/24](#)); Invesco ([8/9/24](#)); PV Magazine ([6/18/24](#)); Reuters ([4/26/24](#); [5/2/24](#), [6/12/24](#)); Utility Dive ([5/7/24](#)); Yahoo Finance ([accessed 8/9/24](#)).

# SREC Pricing

- Solar renewable energy certificate (SREC) pricing has been relatively stable in 2024, although some price movement occurred as states switched to a new energy year in June.
- Prices vary depending on whether SRECs are sold in the spot market or for a forward contract. For example, RECMint estimates an 11%–24% and 33%–46% discount over spot prices for 3- and 5-year contracts, respectively.



Note: DC = Washington, DC; MA = Massachusetts; MD = Maryland; NJ = New Jersey; OH = Ohio; PA = Pennsylvania; VA = Virginia. Sources: [SRECTrade](#), [RECMint](#), accessed 08/20/24.



# Agenda

## 1 Global Solar Deployment

## 2 U.S. PV Deployment

## 3 PV System Pricing

## 4 Global Manufacturing

## 5 Component Pricing

## 6 Market and Policy

## 7 U.S. PV Imports

- In August, the United States increased the quota for tariff-free silicon solar cell imports from 5 GW<sub>dc</sub> to 12.5 GW<sub>dc</sub>, while a U.S. solar group asked Commerce to place retroactive duties on Vietnamese/Thai imports.
- According to U.S. Census data, in Q2 2024, U.S. module imports grew again to nearly 18 GW<sub>dc</sub> (+17% q/q), or 33 GW<sub>dc</sub> for the first half of 2024.
- After several years of relatively steady import volumes, c-Si cell imports have begun to rise substantially as new domestic module manufacturing capacity comes online. According to U.S. Census data, the United States imported more than 3 GW<sub>dc</sub> of cells in Q2 2024—the fourth straight quarter of growth (and third straight 50%+ q/q).

# Recent Tariff News

## United States Increases Tariff-Free Silicon Solar Cell Imports From 5 GW to 12.5 GW

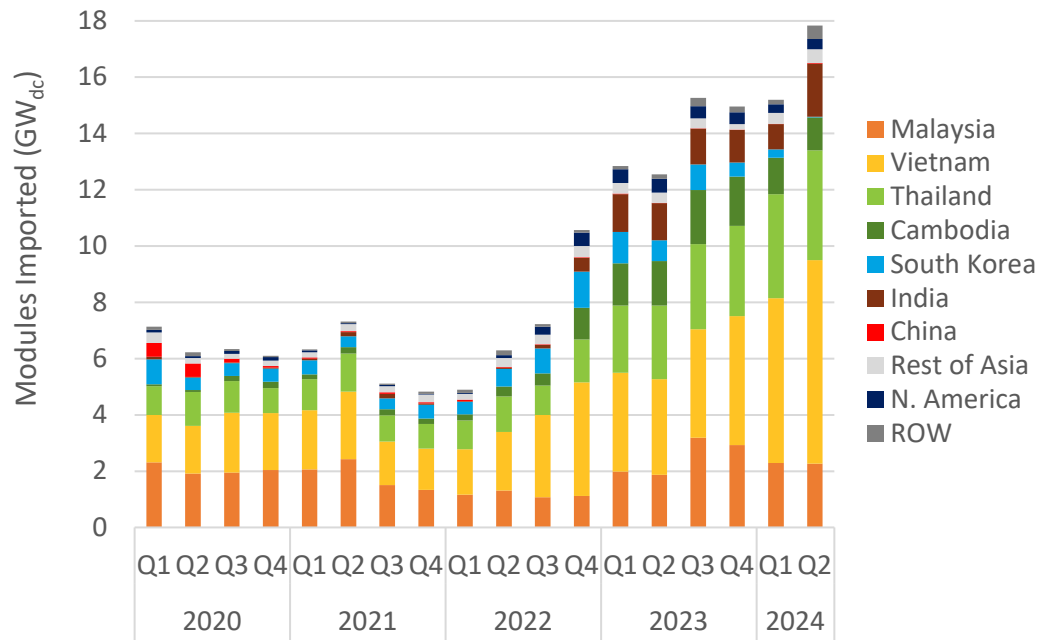
- On August 12, the White House raised the Tariff Rate Quota on imported silicon cells from 5 GW<sub>dc</sub> to 12.5 GW<sub>dc</sub> for the Section 201 Tariffs.
  - 98% of the previous 5-GW<sub>dc</sub> quota had been filled, and a 14.25% tariff would have been imposed on all cells entering the country through February 6, 2025.
- SEIA reported in June and August that between 20<sub>dc</sub> and 30 GW<sub>dc</sub> of domestic c-Si module manufacturing capacity was operational, with no domestic PV cell manufacturing. It is unknown how ramped up these factories are and how many shifts they are operating; however, those facilities would likely need more than the tariff quote for a half year at full utilization.
- Additionally, the potential for further AD/CVD on Southeast Asian cells may drive more imports before a decision is made.
- Imports over the next few months may indicate if a further increase is necessary before domestic c-Si cell manufacturing comes online.

## U.S. Solar Group Seeks Retroactive Duties on Vietnamese/Thai Imports

- In August, a group of U.S. solar panel makers filed a “critical circumstances” allegation, asking the Commerce Department to impose retroactive duties on solar cells and modules imported from Thailand and Vietnam because of a surge in imports.
  - The countries currently face an AD/CVD investigation.
  - Critical circumstances occur when there is a significant increase in imports while a product is under investigation.
- If Commerce and the ITC find that critical circumstance occurred, they can impose tariffs 90 days retroactively from the time a preliminary determination is made.

# U.S. Module Imports Q2 2024 by Region

U.S. Module (c-Si + CdTe) Imports by Region



According to U.S. Census data, in Q2 2024, U.S. module imports grew again to nearly 18 GW<sub>dc</sub> (+17% q/q), or 33 GW<sub>dc</sub> for the first half of 2024.

- Imports from Vietnam represent an expanding percentage, growing from 27% in Q2 2023 to 41% in Q2 2024. In Q2 2024, Vietnam alone was responsible for 7.2 GW<sub>dc</sub> of modules (6.3 GW of c-Si + 0.9 GW<sub>dc</sub> thin film).
- Imports from India grew significantly again in Q2 2024, accounting for an estimated\* 11% of imports this quarter. In contrast, after experiencing a surge in late 2022/early 2023, module imports from South Korea have fallen to negligible volumes.

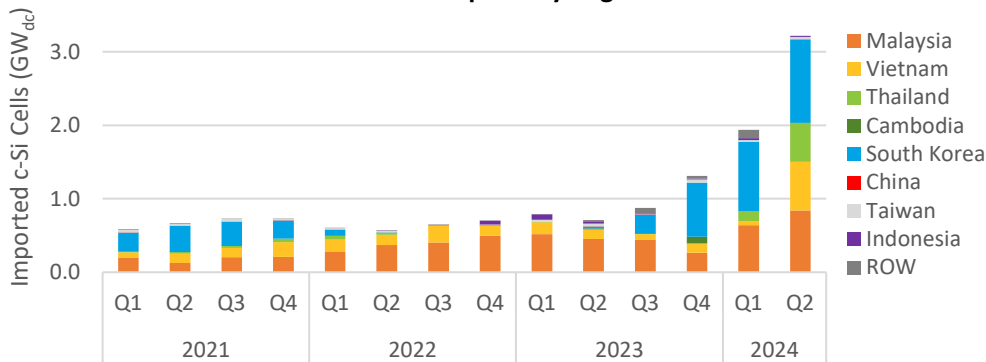
June 6, 2024, marked the end of the moratorium on the collection of AD/CVD circumvention duties, a.k.a. the “solar bridge,” for certain SE Asian manufacturers; however, there was not a noticeable decrease in imports in June. Module imports held steady at 6 GW/month throughout Q2 2024.

# c-Si Cell Import Data Q2 2024

According to U.S. Census data, the U.S. imported over 3 GW<sub>dc</sub> of cells in Q2 2024—the fourth straight quarter of growth (and third straight 50%+ q/q).

- Most of the growth has come from Thailand and Vietnam, which represented 17% (530 MW) and 21% (660 MW), respectively.
- South Korea still represents the largest share of imports with >1 GW imported in Q2.
- Comparing to Q2 2023, c-Si cell imports have more than tripled y/y.

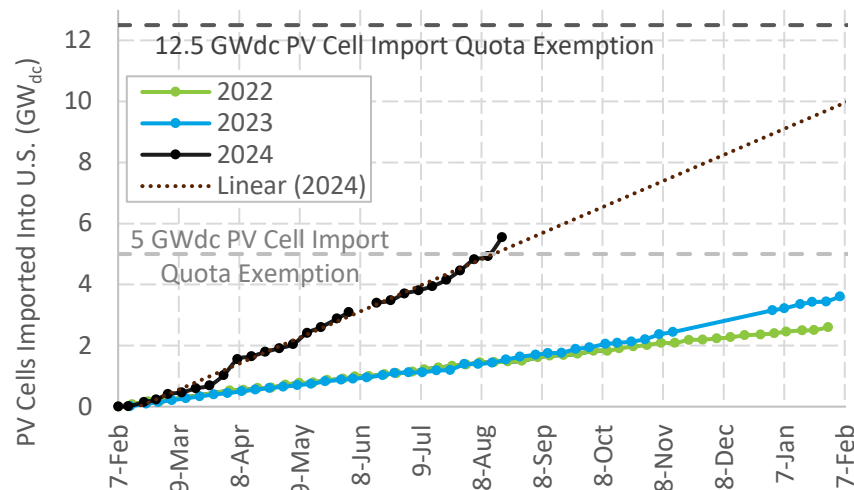
U.S. Cell Imports by Region



After several years of relatively steady import volumes, c-Si cell imports have begun to rise substantially as new domestic module manufacturing capacity comes online.

According to CBP Commodity Status Reports, cell imports since February (the date the annual tariff rate quota for Section 201 Tariffs is counted from) hit 5 GW this past week. As a result, [the president officially raised the TRQ to 12.5 GW<sub>dc</sub> retroactive to August 1, 2024](#). If imports were to continue at their current rate, imports would hit ~10 GW<sub>dc</sub> by February 2025.

c-Si Cell Imports Under the Section 201 Tariff Rate Quota



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 8/6/24; U.S. Customs and Border Protection [Commodity Status Reports](#) February 2019–August 2024.

# South Korean Imports

In 2021, cell and module imports from South Korea were relatively steady, with cells accounting for one-third to one-half of imports each quarter.

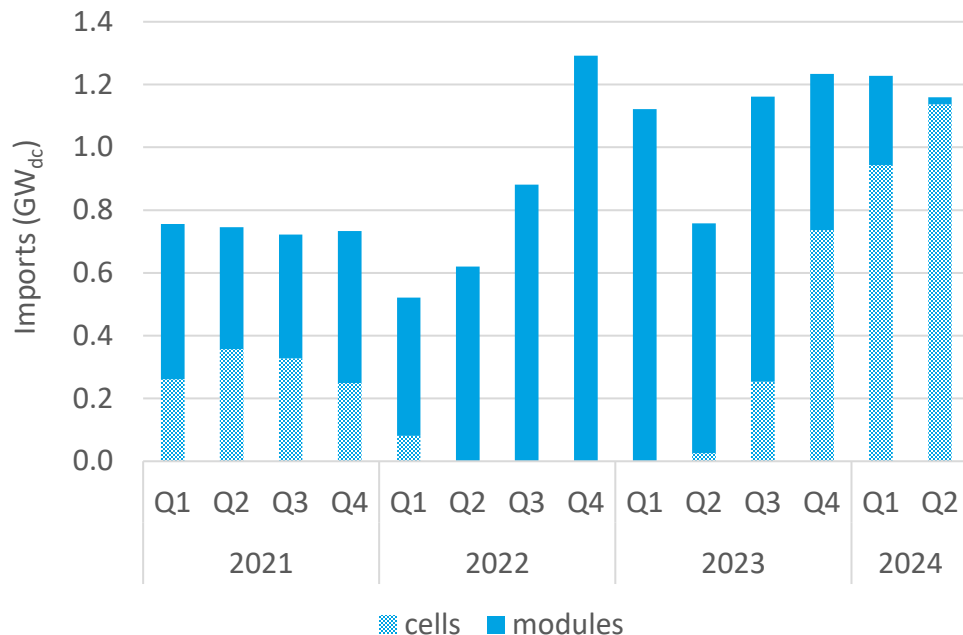
However, 2022 saw a significant shift in both the volume and balance of imports, with module imports tripling as cell imports dropped to negligible volumes for more than a year.

This trend reversed itself in 2023, with cell imports growing to represent 98% of imports from South Korea in Q2 2024 as module imports fell to negligible levels. However, the overall volume of imports remained 1.5× higher than in 2021.

This can be explained in large part by the activities of Hanwha Qcells, a major South Korean manufacturer with operations in the United States.

- In 2023, Hanwha shut down production at its 3.5-GW module facility in Eumseong, South Korea.
- At the same time, production began ramping up at their new/newly expanded facilities in Georgia, which require imported cells until their domestic cell production capacity comes online at the end of the year.
- Hanwha also has 1 to 1.5 GW of cell production capacity in Malaysia, which is providing the remaining cells.

## South Korean c-Si Cell and Module Imports



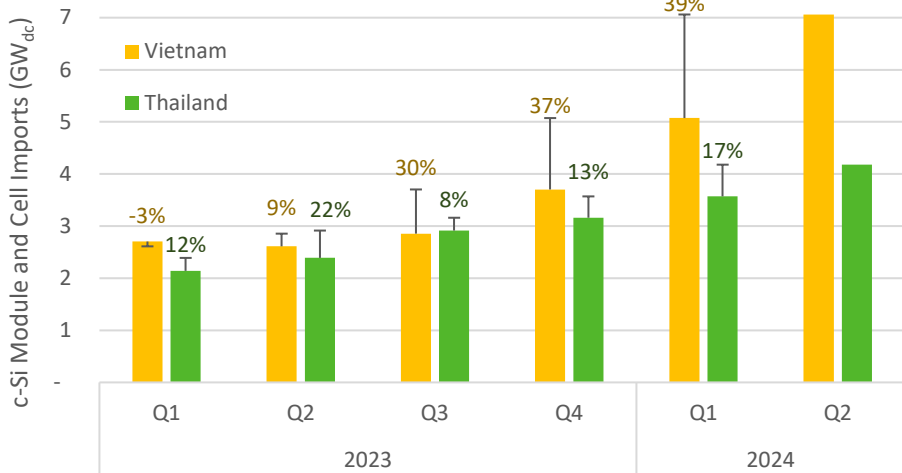
# Vietnamese and Thai Imports

In Q2 2024, imports of modules and cells combined from both Vietnam (+39% q/q) and Thailand (+17% q/q) grew.

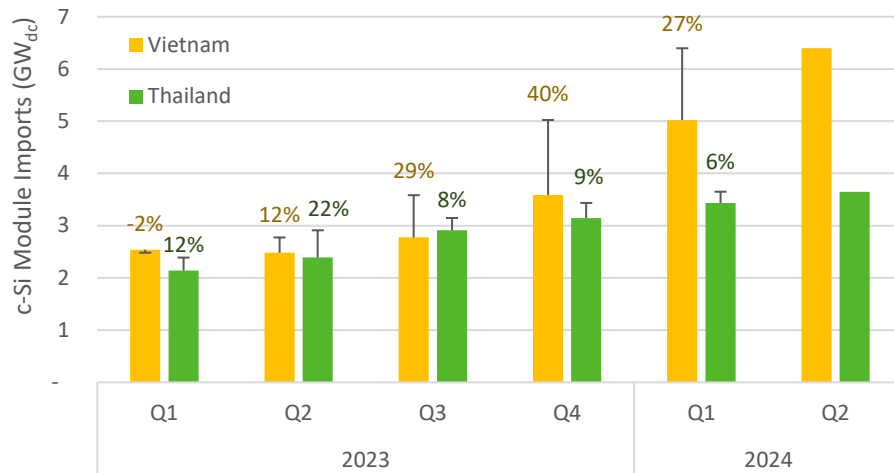
However, the preceding two quarters had also seen significant growth, with Q2 part of a trend of growing imports.

Removing cell imports—which are supporting the burgeoning domestic module manufacturing industry—the growth is significantly less, with Vietnam and Thailand growing only 27% and 6% q/q in Q2 2024, respectively.

Quarterly c-Si Module and Cell Imports for Vietnam and Thailand



Quarterly c-Si Module Imports for Vietnam and Thailand



Sources: Imports by HTS code: 8541460025(2018-2021)/8541420010(2022-) and 8541460035(2018-2021)/8541430010(2022-), Second Quantity (watts) from U.S. Census Bureau [USA Trade Online tool](https://www.trade.gov/usa-trade-online-tool) and [corrections page](#) as of 8/6/24.



# Solar Industry Update

NREL | Colorado, United States

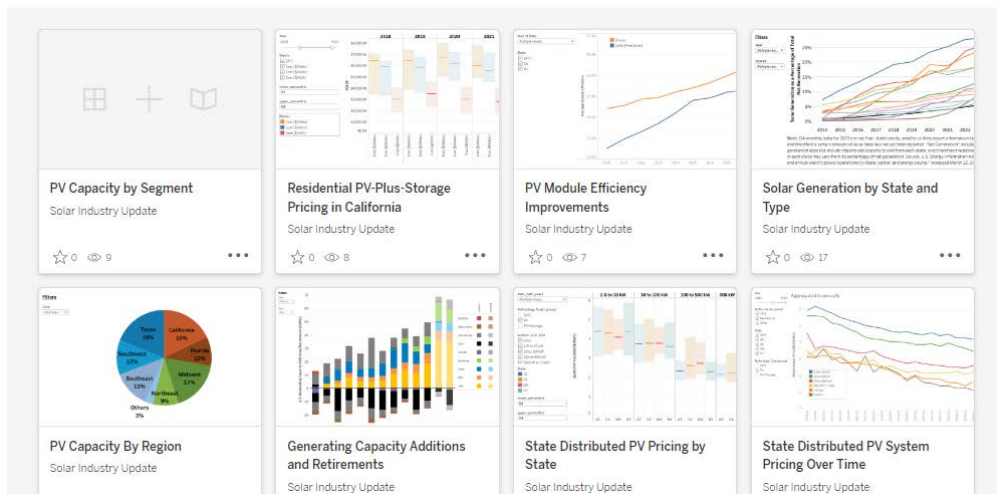
Quarterly presentation of technical trends within the solar industry. Each presentation focuses on global and U.S. supply and demand, module and system price, investment trends and business models, and updates on U.S. government programs supporting the solar industry.

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# Thank You

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[www.nrel.gov](http://www.nrel.gov)

NREL/PR-7A40-91209

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# List of Acronyms and Abbreviations

**ac:** alternating current

**AD:** antidumping

**ALMM:** approved list of module manufacturers

**c-Si:** crystalline silicon

**C&I:** commercial and industrial

**CBP:** U.S. Customs and Border Protection

**CCI:** community, commercial, and industrial

**CdTe:** cadmium telluride

**CFPB:** Financial Protection Bureau

**CPI:** consumer price index

**CPUC:** California Public Utility Commission

**CSP:** concentrating solar power

**CVD:** countervailing duty

**dc:** direct current

**DOE:** U.S. Department of Energy

**EIA:** U.S. Energy Information Administration

**ERCOT:** Electric Reliability Council of Texas

**ETF:** exchange-traded fund

**EU-27:** European Union

**FERC:** Federal Energy Regulatory Commission

**FTC:** Federal Trade Commission

**G&A:** general and administrative

**GW:** gigawatt

**GWh:** gigawatt-hour

**H1:** first half of year

**H2:** second half of year

**HTS:** harmonized tariff schedule

**IEA:** International Energy Agency

**IRA:** Inflation Reduction Act of 2022

**ISO:** independent System Operator

**ITC:** investment tax credit

**kg:** kilogram

**kW:** kilowatt

**kWh:** kilowatt-hour

**LBNL:** Lawrence Berkeley National Laboratory

**LMI:** low- and moderate-income

**M:** million

**MW:** megawatt

**MWh:** megawatt-hour

**NEM:** net energy metering

**NREL:** National Renewable Energy Laboratory

**PPA:** power purchase agreement

**PV:** photovoltaics

**Q:** quarter

**q/q:** quarter over quarter

**ROW:** rest of world

**SEIA:** Solar Energy Industries Association

**SETO:** Solar Energy Technology Office

**SolarAPP+:** Solar Automated Permit Processing+

**SREC:** solar renewable energy certificate

**TAN:** Invesco Solar ETF

**TOPCon:** tunnel oxide passivated contact

**TRQ:** tariff rate quota

**TW:** terawatt

**TWh:** terawatt-hour

**UAE:** United Arab Emirates

**UFLPA:** Uyghur Forced Labor Prevention Act

**USD:** U.S. dollars

**USEER:** United States Energy and Employment Jobs Report

**W:** watt

**Wt avg:** weighted average

**Y:** year

**y/y:** year over year

**YTD:** year to date