



# Q2/Q3 2020 Solar Industry Update

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# Executive Summary

## Global Solar Deployment

- The median estimate of 2020 global PV system deployment projects an 8% y/y increase to approximately 132 GWDC.

## U.S. PV Deployment

- Despite the impact of the pandemic on the overall economy, the United States installed 9.0 GWAC (11.1 GWDC) of PV in the first 9 months of 2020—its largest first 9-month total ever.
- At the end of September, there were 67.9 GWAC (87.1 GWDC) of solar PV systems in the United States.
- Based on EIA data through September 2020, 49.4 GWAC of new electric generating capacity are *planned* to come online in 2020, 80% of which will be wind and solar; a significant portion is expected to come in Q4.
- EIA estimates solar will install 17 GWAC in 2020 and 2021, with approximately 13 GWAC from large-scale PV.
- The United States installed approximately 497 MWh (266 MWAC) of energy storage onto the electric grid in H1 2020, up 3% y/y, as a result of record levels of behind-the-meter deployment.

## PV System and Component Pricing

- The median residential quote from EnergySage in H1 2020 fell 2.4%, y/y to \$2.85/W—a slower rate of decline than observed in any previous 12-month period.
- Even with supply-chain disruptions, BNEF reported global mono c-Si module pricing around \$0.20/W and multi c-Si module pricing around \$0.17/W.
- In Q2 2020, U.S. mono c-Si module prices fell, dropping to their lowest recorded level, but they were still trading at a 77% premium over global ASP.

## Global Manufacturing

- Despite tariffs, PV modules and cells are being imported into the United States at historically high levels—20.6 GWDC of PV modules and 1.7 GWDC of PV cells in the first 9 months of 2020.
- In H1 2020, U.S. c-Si module production dipped 9% from the historical high it reached in H2 2019, due to the pandemic.
- In H1 2020, U.S. PV cell production decreased 66% from H2 2019 and virtually no panels were produced in Q2 2020.

# 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 Activity

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Global Soft Costs Trends

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## 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 Activity

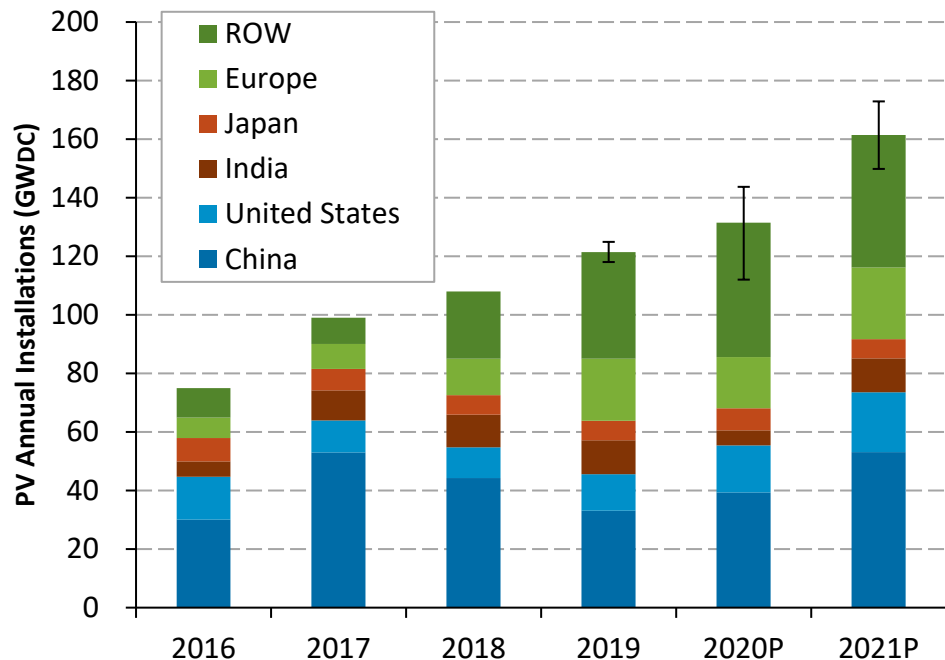
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## Global Soft Costs Trends

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- **The median estimate of 2020 global PV system deployment projects an 8% y/y increase to approximately 132 GW<sub>DC</sub>.**
- **Analysts expect increased deployment in 2021 as well, with strong growth in many of the leading markets.**
  - If analysts are correct, there will be more than 900 GW<sub>DC</sub> of global PV by the end of 2021.

# Annual Global PV Demand



**Notes:** P = projection. Bar represents median projection. Error bars represent high and low projections. Not all sources have data for all categories.

**Sources:** BNEF, “4Q 2020 Global PV Market Outlook,” 11/24/20; Infolink (November 2020) (Solar Power Europe [Global Market Outlook 2020-2024](#), “Wood Mackenzie Power and Renewables (November 2020, October 2020).

- Though most analysts estimate an increase in global PV installations in 2020, projections range from 112 GWDC to 144 GWDC.
  - The median estimate of 2020 global PV system deployment projects an 8% y/y increase to approximately 132 GWDC.
  - Between 2019 and 2020, annual PV installations in Europe and India are estimated to shrink. Chinese, U.S., Japanese, and ROW PV installations are projected to grow.
- Analysts expect increased deployment in 2021 as well, with strong growth in many of the leading markets.
  - If analysts are correct, there will be more than 900 GWDC of global PV by the end of 2021.

# CSP Updates

- In September, China's Delingha CSP tower plant, with seven hours of storage, reported it had produced 89% of long-term expected production in its first year—typical international first-year rates are 70%–80%.
  - The main drivers in the loss of production were equipment failure, lack of operational experience, and grid curtailment.
- In September, Abengoa completed the first of three 200 MWAC parabolic trough solar fields at the 950 MWAC Noor Energy 1 CSP-PV plant in Dubai.
  - In June, Shangai Electric completed the project's CSP tower receiver.
- In September, Q-Energy, a subsidiary of a Spanish investment group, purchased 67 MWAC of CSP plants, expanding its portfolio to 170 MWAC of CSP. United Kingdom-based investment fund Cubico also recently expanded its CSP portfolio to 150 MWAC, continuing the trend of Spanish CSP asset acquisitions.
- In November, a group of European companies announced they would build a pilot ceramic particle concentrating solar tower plant to supply heat for a pasta factory in Italy.
  - The “centrifugal solar technology” was designed by the German Aerospace Centre and has achieved temperatures as high as 965° Celsius at the receiver outlet during tests. Conventional molten-salt CSP plants operate up to 565° Celsius. Higher temperatures increase plant efficiency but place more stress on the system.

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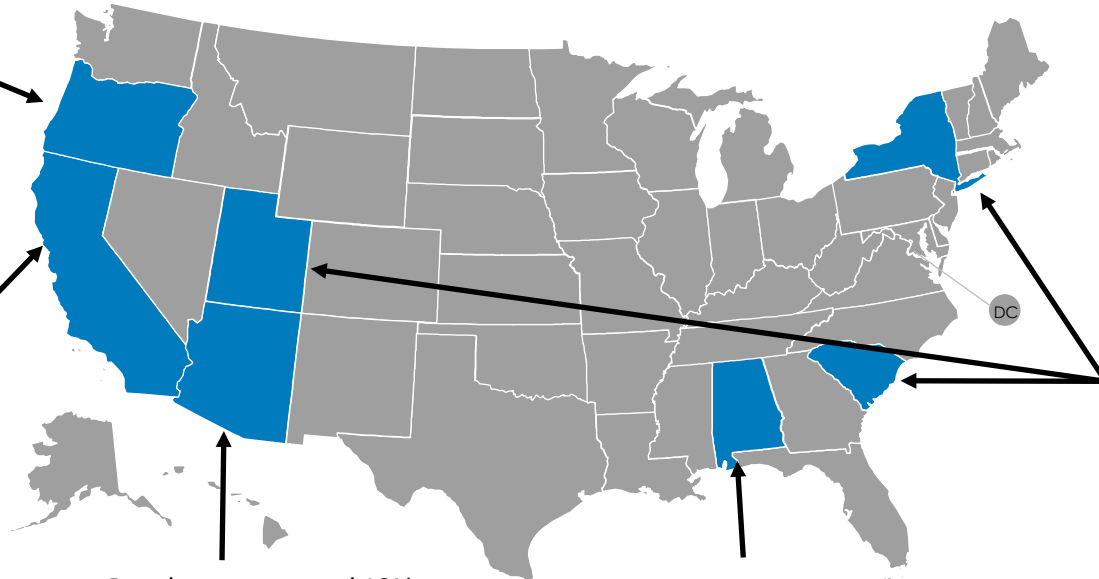
## Global Soft Costs Trends

- Despite the impact of the pandemic on the overall economy, the United States installed 9.0 GWac (11.1 GWdc) of PV in the first 9 months of 2020—its largest first 9-month total ever.
- At the end of September, there were 67.9 GWac (87.1Dc) of solar PV systems in the United States.
- Based on EIA data through September 2020, 49.4 GWac of new electric generating capacity are *planned* to come online in 2020, 80% of which will be wind and solar; a significant portion is expected to come in Q4.
- EIA estimates solar will install 17 GWac in 2020 and 2021, with approximately 13 GWac from large-scale PV.
- The United States installed approximately 497 MWh (266 MWac) of energy storage onto the electric grid in H1 2020, up 3% y/y, as a result of record levels of behind-the-meter deployment.

# State Updates

IOUs launched community solar programs.

The CPUC kicked off efforts to find successor to net metering program 2.0 (i.e., net metering 3.0). The CPUC released a draft study finding residential customers paid too little and non-residential customers paid too much for PV in 2.0 program.



Regulators approved 10% PV energy export rate reduction starting in October 2021.

Regulators upheld legality of PV fee and approved an increase (from from \$5/kW to \$5.41/kW).

These states approved net metering successor programs with monthly charges per kW (NY), minimum bills (South Carolina), time-of-use rates (South Carolina), and ability to make changes in the future (Utah).

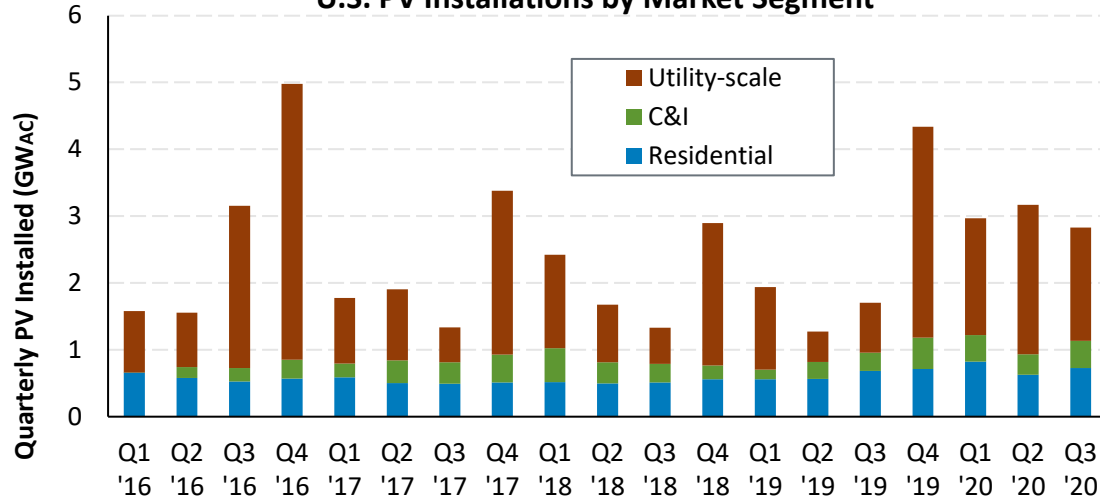


# U.S. Installation Breakdown Quarterly: EIA

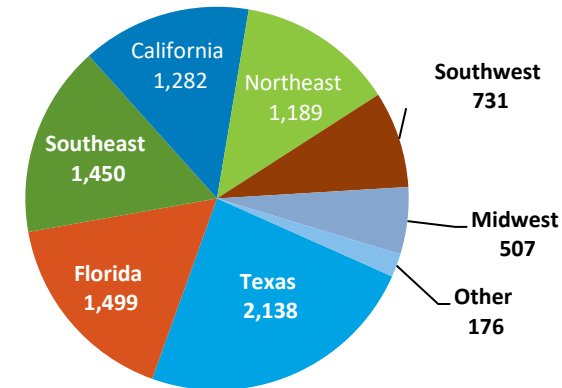
- Despite the impact of the pandemic on the overall economy, the United States installed 9.0 GWac of PV in the first 9 months of 2020, its largest first 9-month total ever—up 82% y/y.
  - Residential, C&I, and utility-scale PV were up 20%, 66%, and 133% over that time period respectively.

- Approximately 55% of U.S. PV capacity installed in the first 9 months of 2020 occurred in Texas, Florida, and California.
- Despite a concentration of PV installations in the top three markets, there continues to be growing diversification of growth across the United States.

U.S. PV Installations by Market Segment



Q1-Q3 2020 U.S. PV Installations by Region (9.0 GWac)

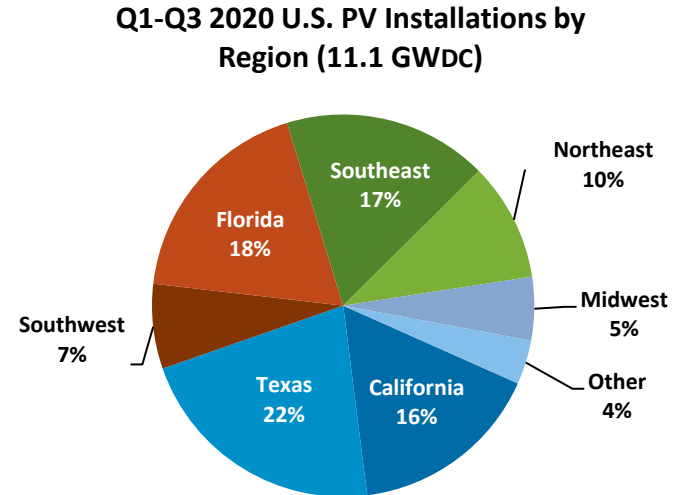
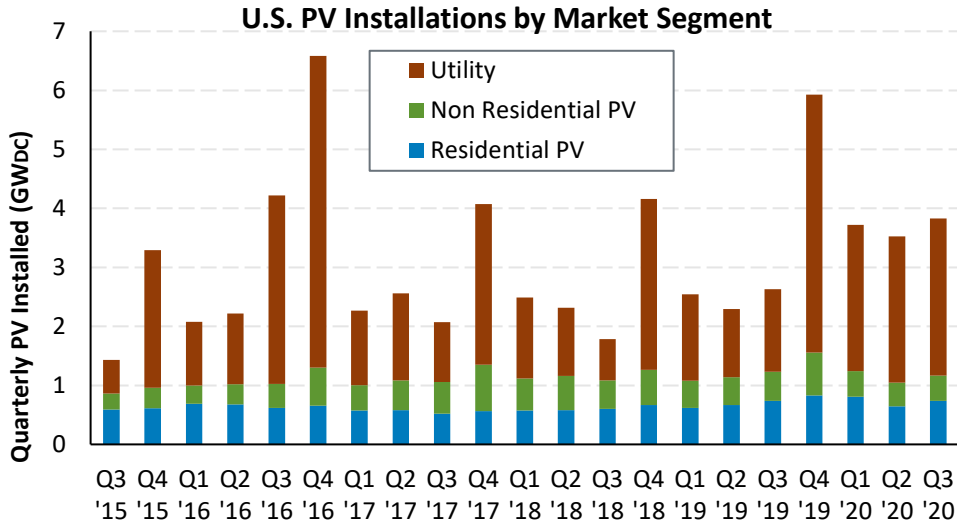


# U.S. Installation Breakdown

## Quarterly: SEIA

- SEIA reports that the United States installed 11.1 GWDC of PV in the first 9 months of 2020—up 48% y/y.
  - At the end of Q3 2020, there were 87.1 GWDC of cumulative PV installations.

- The units SEIA uses to report installations (GWDC) differ from EIA (GWAC); additionally, there are likely differing assumptions of individual project's placed-in-service dates. However, they are consistent in demonstrating U.S. PV capacity's historical growth and regional diversity.

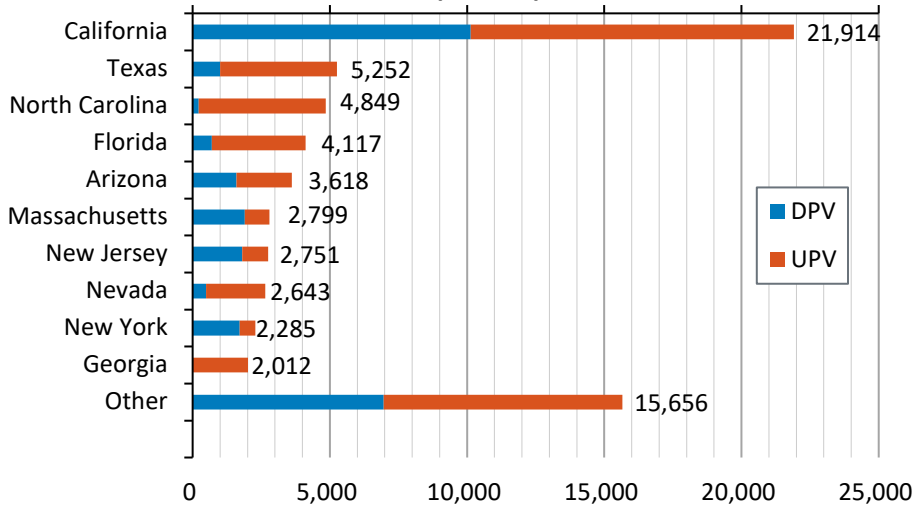


# U.S. Installation Breakdown by State

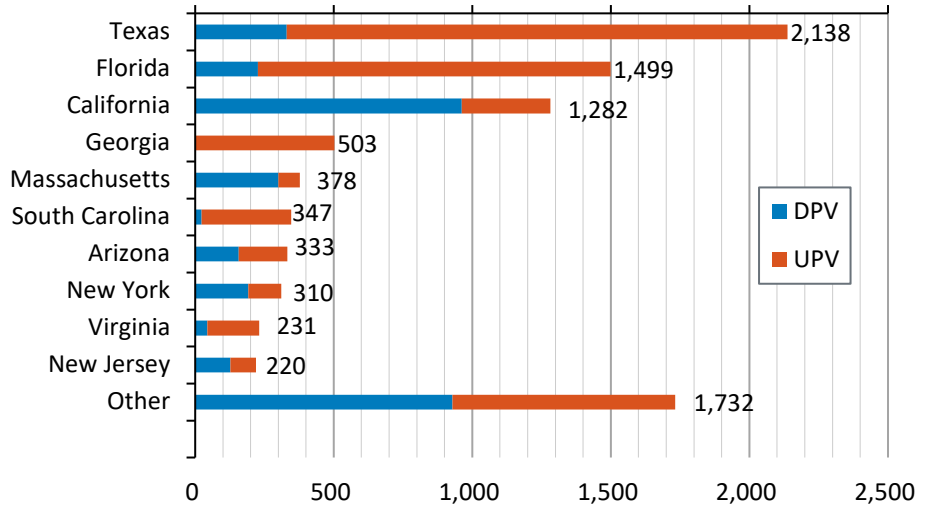
At the end of September, there were 67.9 GWAC of solar PV systems in the United States, of which 41.4 GW were utility-scale PV and 26.5 GW were distributed PV.

In the first 9 months of 2020, approximately 9.0 GWAC of PV capacity were installed, of which 5.7 GWAC were utility-scale PV and 3.3 GWAC were distributed PV.

**Cumulative Installed PV Capacity, as of September 2020 (MWAC)**



**PV Capacity Installed in 2020, as of September (MWAC)**



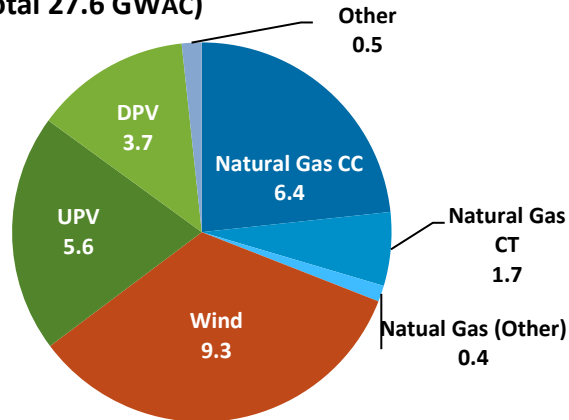
**Note:** EIA monthly data for 2020 are not final. Additionally, smaller utilities report information to EIA on a yearly basis, and therefore, a certain amount of solar data have not yet been reported. "Net Generation" includes DPV generation.

**Sources:** EIA, "Electric Power Monthly," forms EIA-023, EIA-826, and EIA-861 (February and November 2020, February 2019).

# U.S. Generation Capacity Additions by Source: 2019 and *Planned* 2020

- EIA estimates the percentage of U.S. electric capacity additions from solar will grow from 34% in 2019 to 35% in 2020 (26% UPV and 9% DPV). It is estimated that 47% of additions will come from wind in 2020—up from 34% in 2019.
- Based on data through September 2020, solar capacity additions are expected to increase from 2019 installations by more than about 8 GWAC, y/y.
- EIA estimates more combined solar and wind will be installed in 2020 than in any other year.

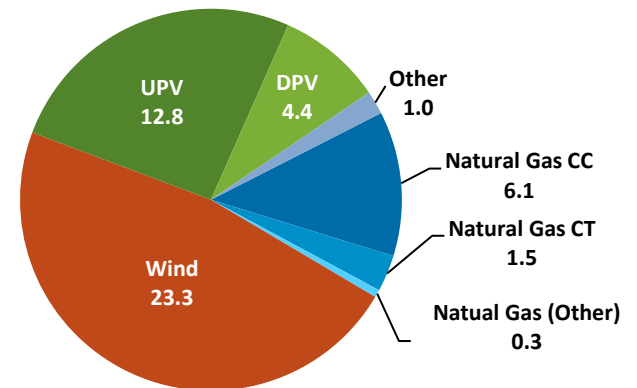
## 2019 U.S. Generation Capacity Additions (Total 27.6 GWAC)



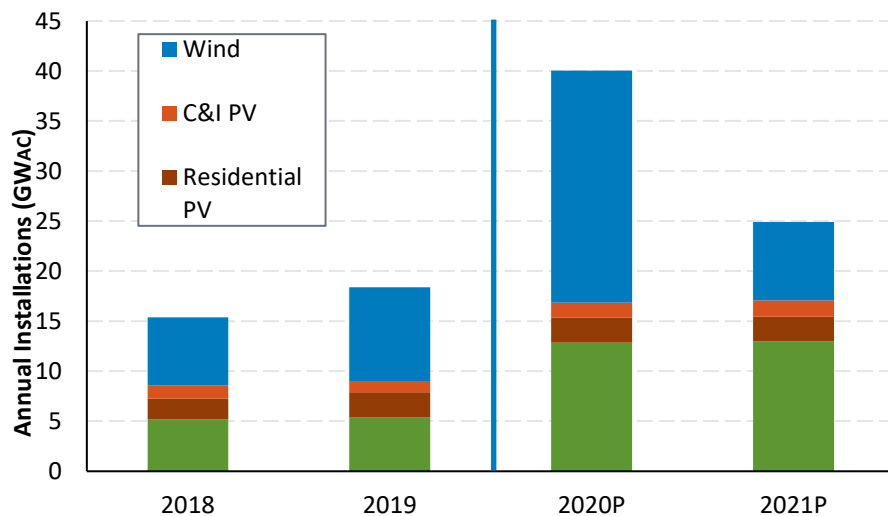
Sources: EIA “Preliminary Monthly Electric Generator Inventory. Solar: EIA “Electric Power Monthly” Table 6.1; 2020 DPV estimate is estimated by multiplying January–September installations by 12/9.

- Based on EIA data through September 2020, 49.4 GWAC of new electric generating capacity are *planned* to come online in 2020—second only to 2002 and roughly double the average over the past 10 years.
  - Only 22 GWAC came online in the first 9 months of 2020; therefore, EIA data expects a massive Q4.
  - In the first 9 months 9.0 GWAC of PV and 5.8 GWAC of wind were installed; another 8.2 GWAC of PV and 17.6 GWAC of wind are expected in Q4 2020.
  - In the last five years, the planned capacity additions in a given year, as of September, have represented 83% to 112% of *actual* installations.
    - Virtually all these projects that are not complete this year will begin operation next year.

## Estimated 2020 U.S. Generation Capacity Additions (Total 49.4 GWAC)



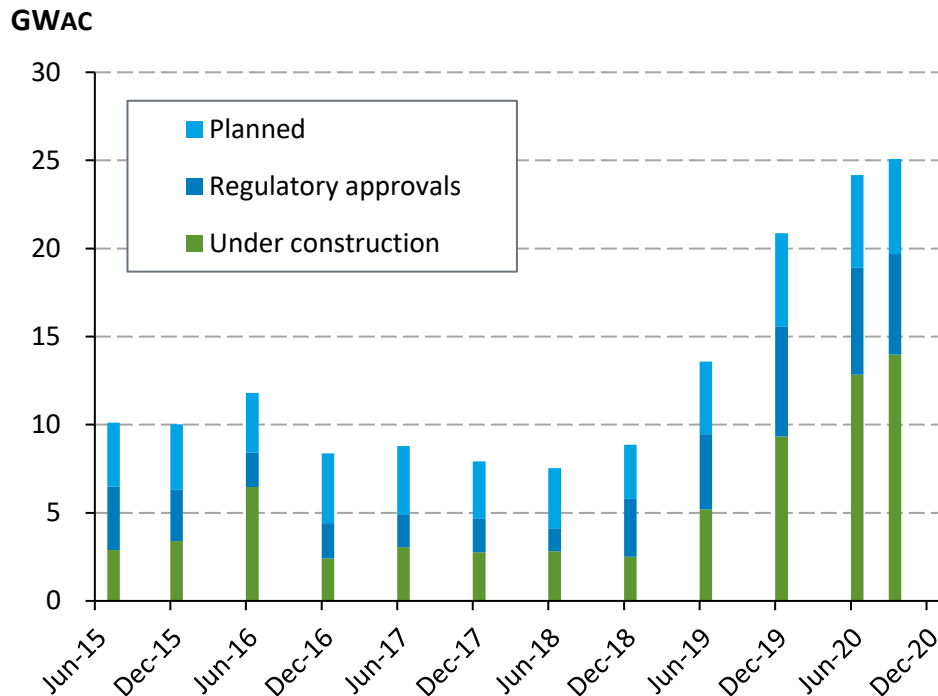
# EIA Historical 2018–2019 and Projected 2020–2021 U.S. Wind and Solar Capacity Additions



Though 2019 U.S. solar and wind installations collectively achieved record levels, EIA expects 2020 and 2021 installations to far exceed these levels, with 40 GWAC in 2020 and 25 GWAC in 2021.

- Wind installations are projected to peak in 2020 with 23 GWAC.
- EIA estimates solar will install 17 GWAC in 2020 and 2021, with approximately 13 GWAC from large-scale PV.

# EIA PV Project Planned Pipeline



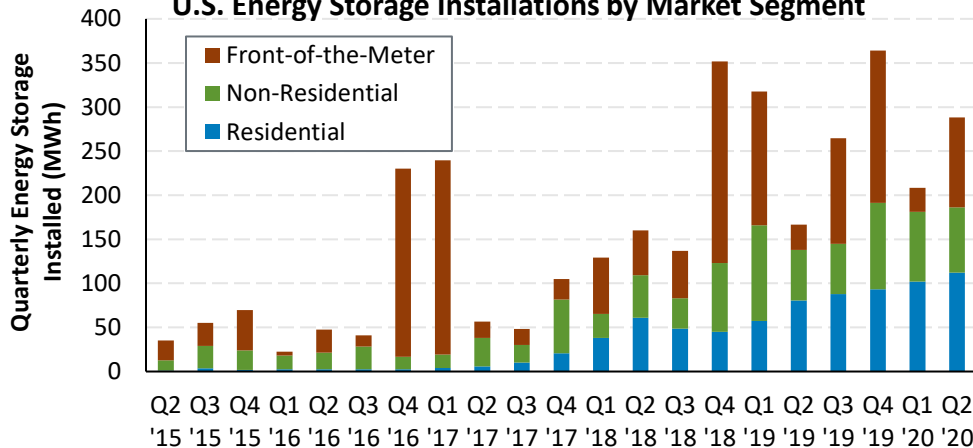
According to EIA data, the U.S. PV project pipeline hit a record high in H1 2019, and the capacity of utility-scale projects under construction was approximately 14 GWAC in September 2020.

# U.S. Energy Storage Installations by Market Segment

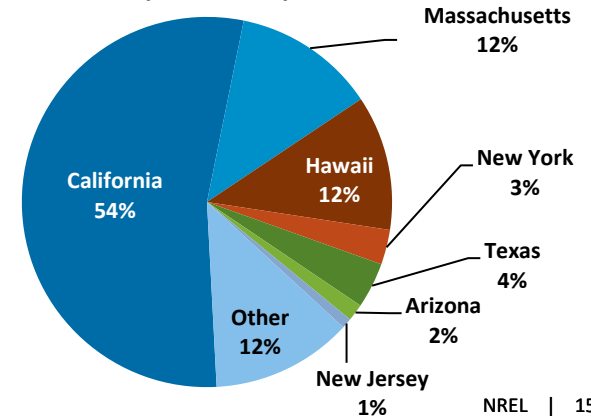
- The United States installed approximately 497 MWh (266 MWAC) of energy storage onto the electric grid in H1 2020, up 3% y/y, due to record levels of behind-the-meter deployment.
  - Increased pairing of PV and batteries, particularly in California and Hawaii, have kept the market strong despite the pandemic-related lockdowns.
  - One California project contributed to 2/3 of the front-of-the-meter MWs deployed in Q2 2020.

- Wood Mackenzie estimates the U.S. energy storage market will grow seven-fold by 2025, driven largely through a dramatic increase in front-of-the-meter installations.
- Over the summer, APS and Tucson Electric in Arizona and Dominion energy in Maryland released integrated resource plans targeting 8.7 GW of energy storage by 2035.
  - 1.9 GW of battery storage were installed in the United States at the end of Q3 2020.

U.S. Energy Storage Installations by Market Segment



H1 2020 U.S. Energy Storage Installations by Region (497 MWh)



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

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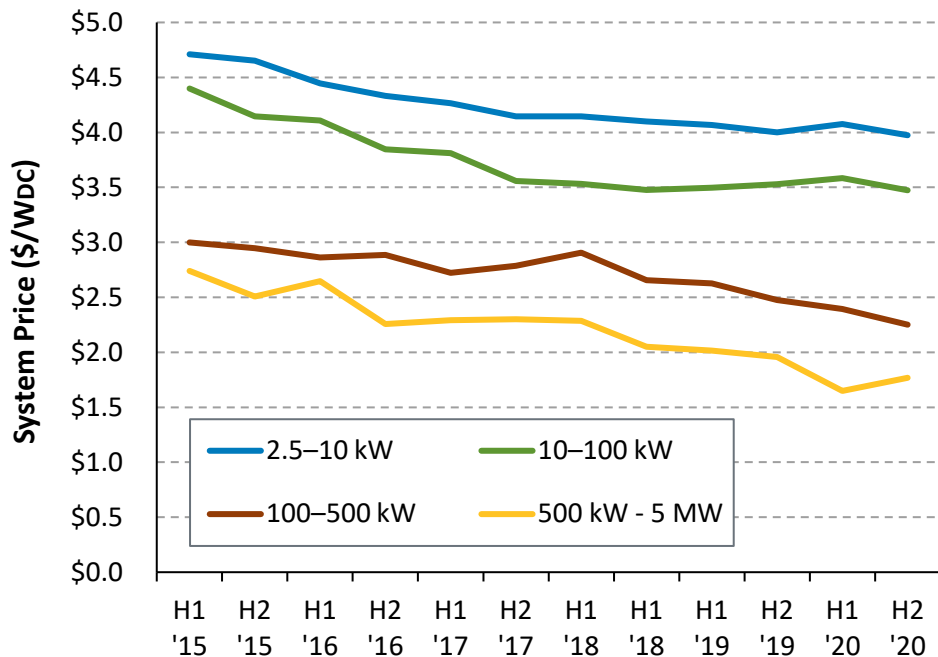
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## Global Soft Costs Trends

- The median residential quote from EnergySage in H1 2020 fell 2.4%, y/y to \$2.85/W—a slower rate of decline than observed in any previous 12-month period.
- From 2018 through 2020 (YTD), PV+storage systems had a median price of \$2,700/kWh, or \$5,900/kWAC.
- LBNL found that the median price of a U.S. utility-scale PV system dropped 20% from 2018 to 2019 to \$1.44/WAC (or \$1.15/WDC).
- LBNL also found that median U.S. PPA pricing has been relatively stable over the past three years with average pricing between \$20-\$30/MWh for non-Hawaii large-scale PV systems.
- For the first time we are including reported pricing data of PV+storage systems in our quarterly updates. From 2018 through 2020 (YTD), U.S. residential PV+storage systems had a median price of \$2,700/kWh, or \$5,900/kWAC.



# System Pricing from Select States



- It is unclear what, if any impact the reduction of the residential ITC from 30% to 26% in 2020 had on reported prices for smaller systems, on average.
- From H2 2019 to H2 2020, the median reported PV system price in Arizona, California, Connecticut, Massachusetts, and New York:
  - Fell 1% to \$3.97/W for systems from 2.5 kW to 10 kW
  - Fell 2% to \$3.47/W for systems from 10 kW to 100 kW
  - Fell 9% to \$2.25/W for systems from 100 kW to 500 kW
  - Fell 10% to \$1.77/W for systems from 500 kW to 5 MW.

**2020 (YTD) MW:** AZ (128), CA (351), CT (2.5), MA (69), NY (279)

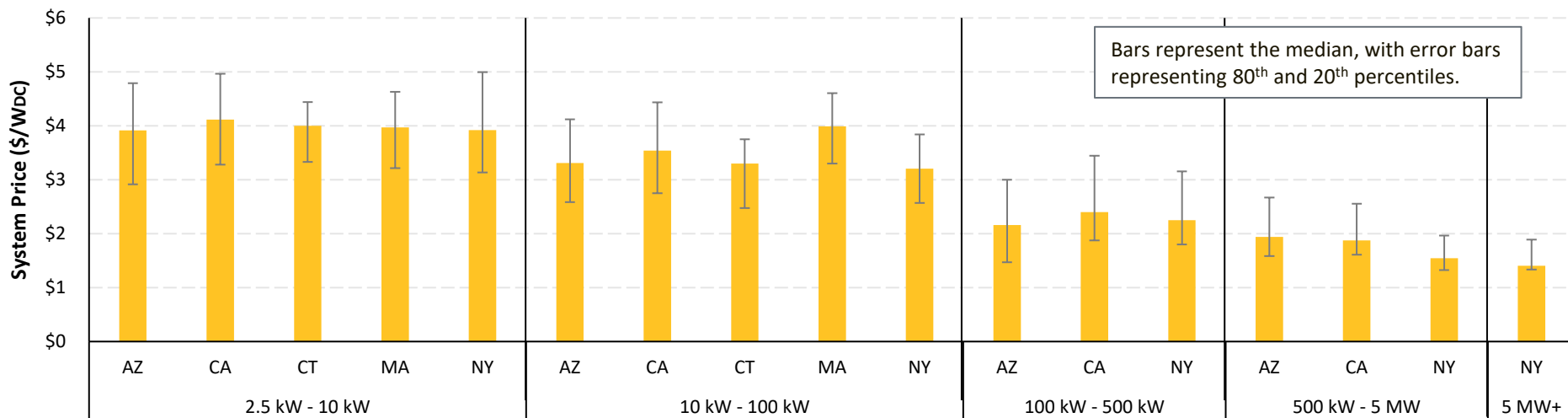
**Note:** System prices above \$10/W and below \$1/W were removed from the data set. There were not enough reported prices for systems above 5 MW in this dataset to show a trends over time.

Sources: AZ (11/24/20), CA NEM database (08/31/20); CT (08/01/20), MA SREC and SMART programs (11/21/20); NYSERDA (11/24/20).

# System Pricing From Select States, 2020 YTD

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

- The median price of a large system in New York was about 28% less than the median price in California.
- In H1 2020, the 20<sup>th</sup> and 80<sup>th</sup> percentile preliminary prices in California for a small system were \$3.39/W and \$5.22/W respectively.



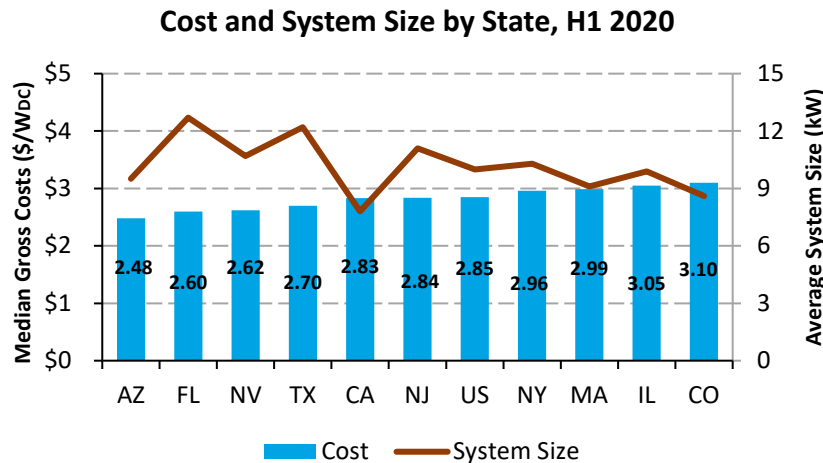
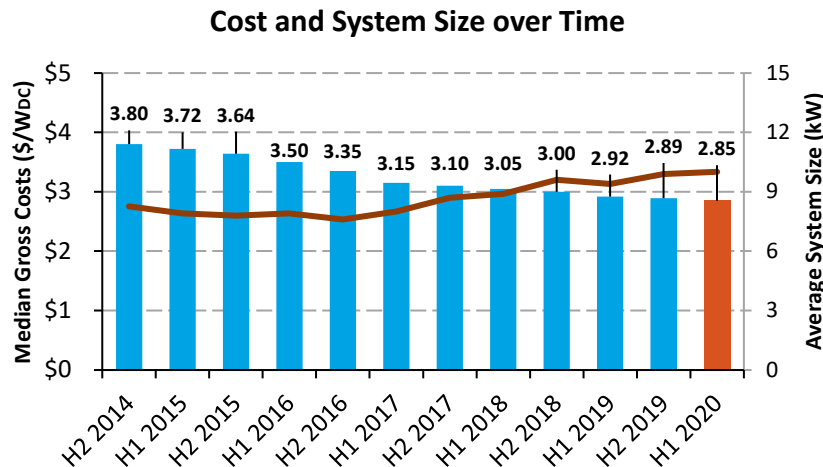
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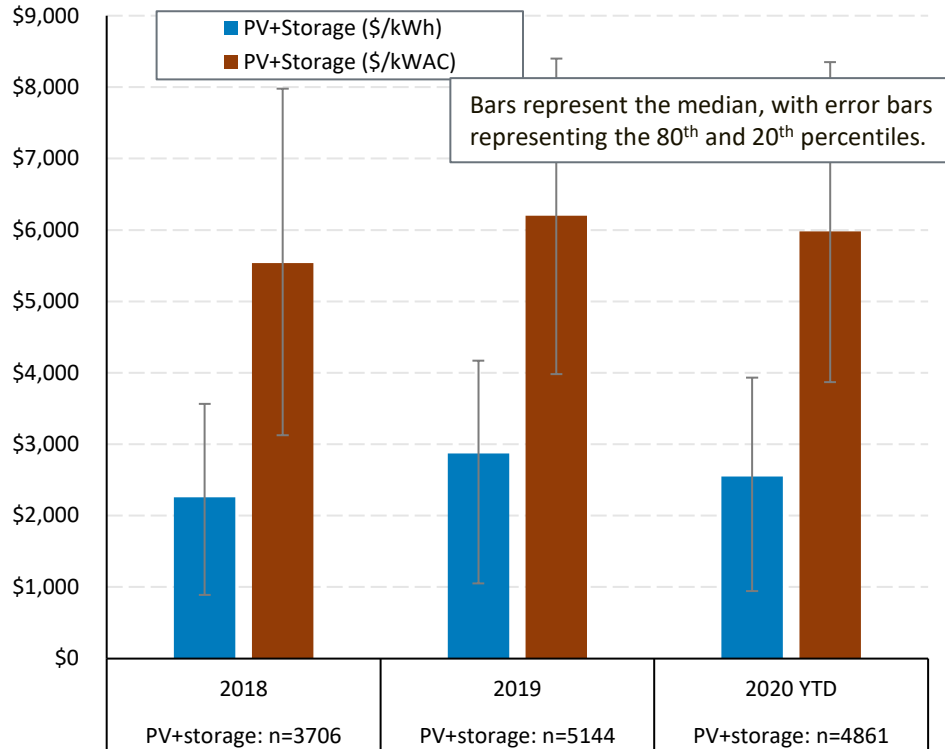
Sources: AZ (11/24/20), CA NEM database (08/31/20); CT (08/01/20), MA SREC and SMART programs (11/21/20); NYSERDA (11/24/20).

# Residential System Costs Reported by EnergySage, H1 2020

- The 2.4% cost decrease between H1 2019 and H1 2020 is a slower rate of decline than observed in any previous 12-month period.
  - Some of the decrease in price can be attributed to a 6.4% increase in system size, to 10.0 kW
- Residential system quotes varied by state. In H1 2020, the median gross cost of a residential system in Colorado was 25% higher than the median gross cost of a residential system in Arizona.
  - Part of the price disparity between states is due to differences in average system size, though other factors, such as cost of living (e.g., California) also play a role.



# Residential U.S. Storage Pricing

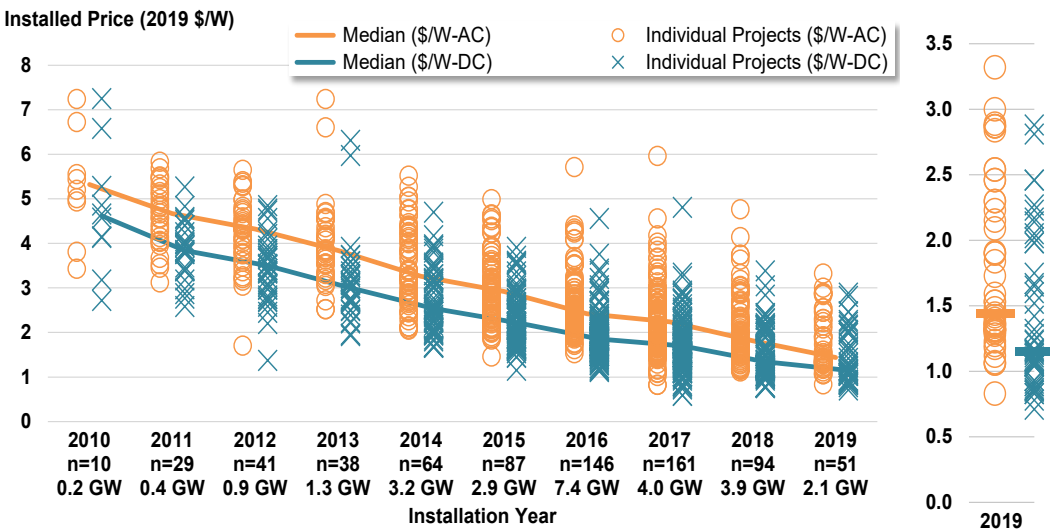


From 2018 through 2020 (YTD), PV+storage systems had a median price of \$2,700/kWh, or \$5,900/kWAC.

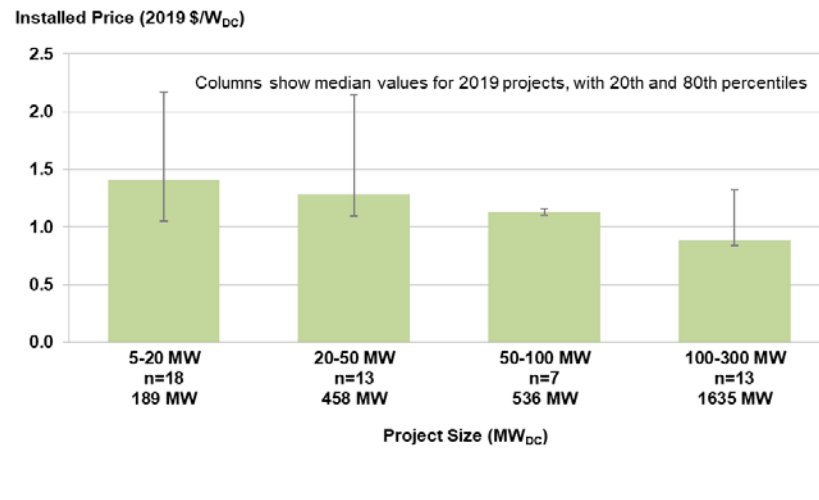
- Most of these systems offer 2–3 hours of storage and have standard capacities of 27.0 kWh, 13.5 kWh, and 9.8 kWh.

# Reported Price of U.S. Utility-Scale PV Projects Over Time

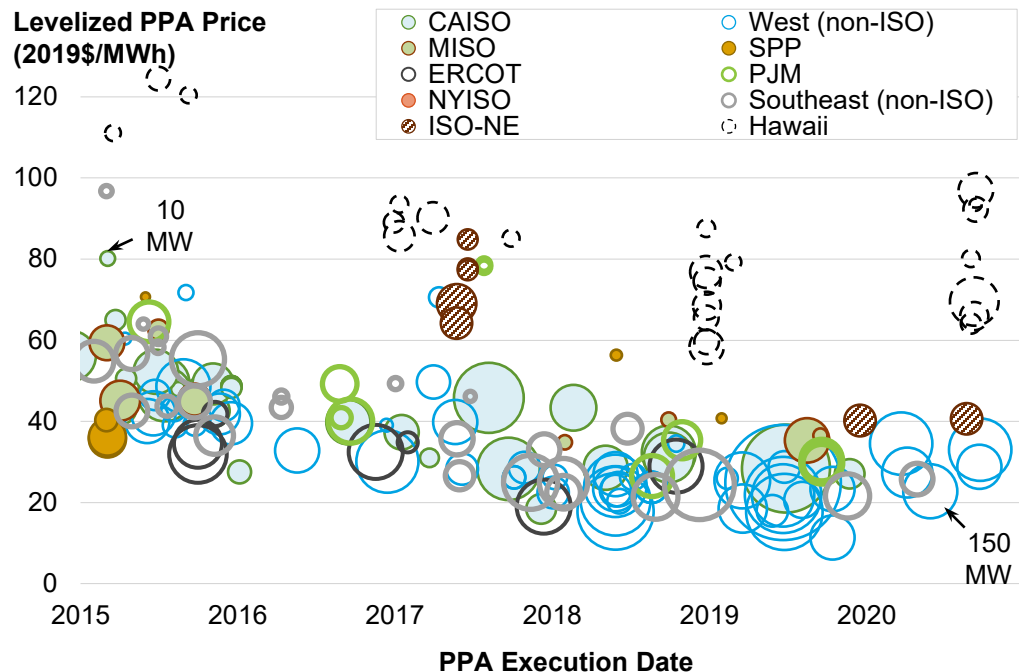
- The median installed price of PV has fallen by nearly 70% since 2010, and 20% since 2018, to \$1.44/W<sub>AC</sub> (\$1.15/W<sub>DC</sub>) in 2019.
- The lowest 20th percentile of project prices fell below \$1.3/W<sub>AC</sub> (\$0.9/W<sub>DC</sub>) in 2019.



- Economies of scale are evident in the 2019 project cost data, with the median price of systems which were 100–300 MW in size 37% lower than the median price of PV systems which were 5–20 MW in size.
- The historical up-front cost premium for tracking has diminished, with the median price of trackers within 4-6 cents/W of the median price of fixed-tilt systems in 2018 and 2019.
- This sample is backward-looking and may not reflect the price of projects built in 2020 and 2021.



# U.S. Utility-Scale PV PPA Pricing

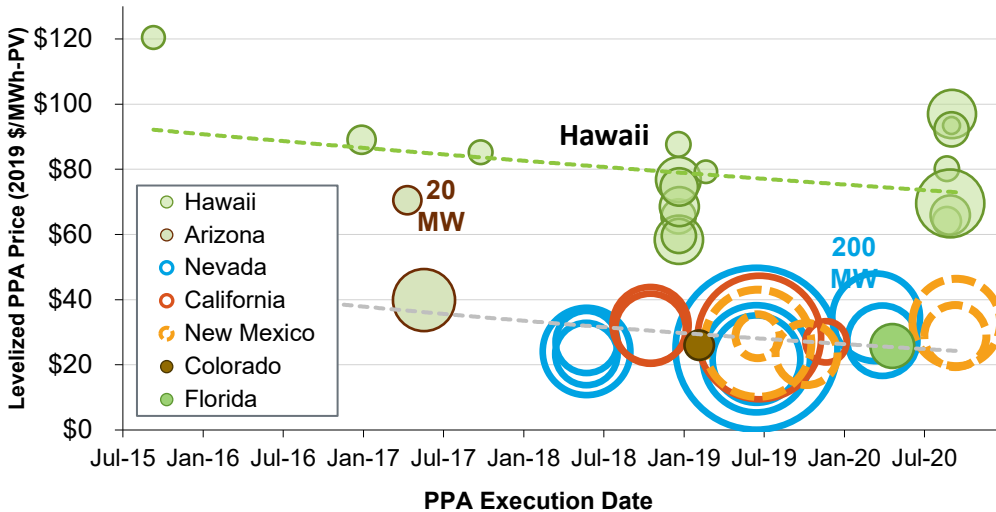


The non-Hawaii generation-weighted average PPA price fell 4% y/y to \$24.8/MWh in 2019, but partial-year 2020 data show an increase in the average to \$30.3/MWh.

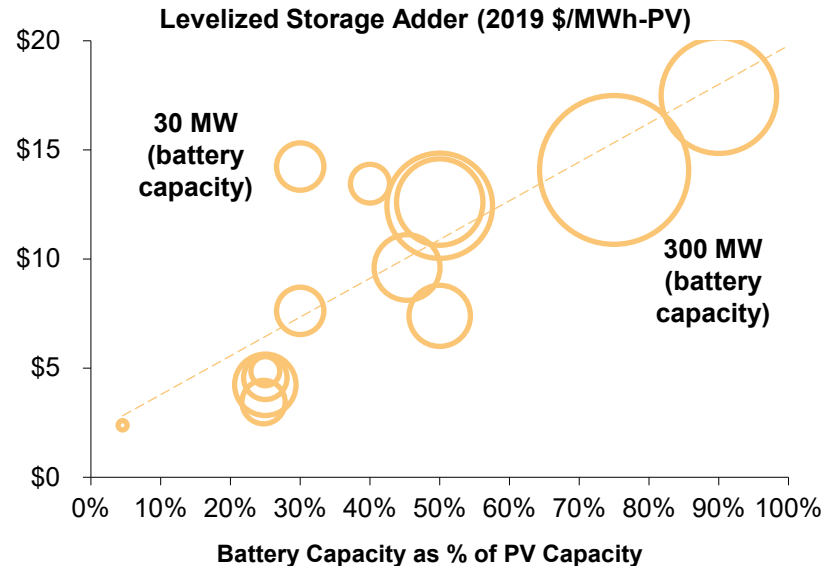
- Since 2015, the generation-weighted average price has fallen 46%.
- Hawaii prices are higher because of the unique nature of its market.

# U.S. Utility-Scale PV+Battery PPA Pricing

- LBNL also collected pricing data from a sample of PV+battery hybrid systems, which includes 39 PPAs in 7 states totaling 4.2 GWAC of PV and 2.3 GWAC of batteries.
- Since 2015, the overall trendline in PPA price trends downwards.



- As to be expected, the premium on storage (relative to a PV-standalone PPA price) is highly dependent on the amount of storage added (relative to the size of the PV system).



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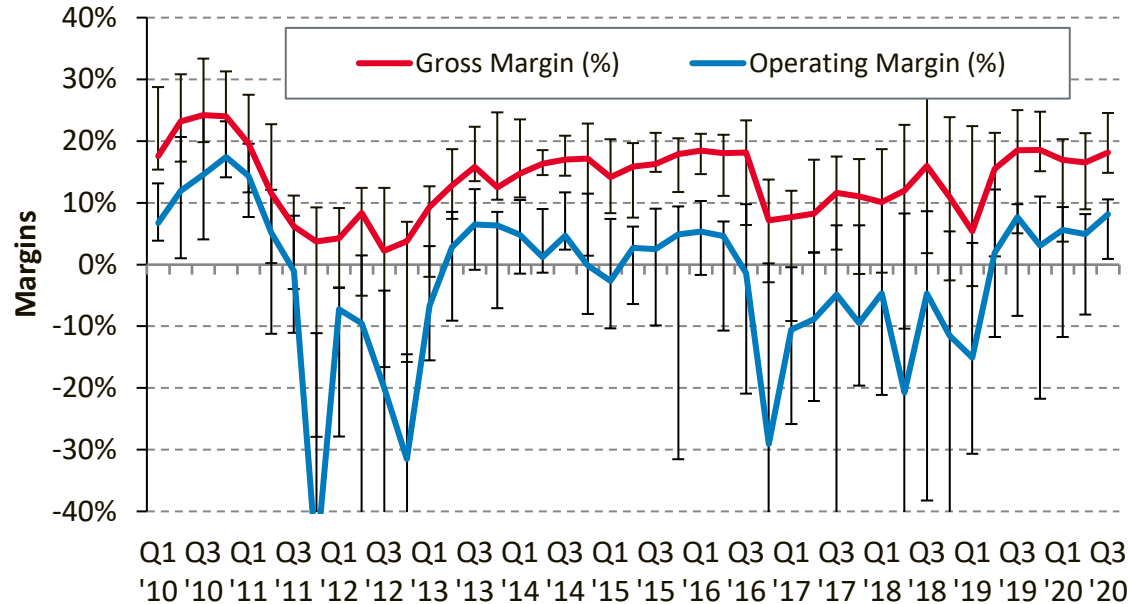
## 6 Market Activity

## Global Soft Costs Trends

- Though PV module and component pricing are still at historically low levels, many companies are still finding ways to remain profitable.
- Despite tariffs, PV modules and cells are being imported into the United States at historically high levels, with 20.6 GWDC of PV modules and 1.7 GWDC of PV cells being imported in the first 9 months of 2020.
  - Also, First Solar’s 1.9-GWDC thin-film plant was operating at a high utilization rate.
- In H1 2020, U.S. c-Si module production dipped 9% from the historical high it reached in H2 2019, because of pandemic-related factors.
- In H1 2020, U.S. PV cell production decreased 66% from H2 2019, and virtually no panels were produced in Q2 2020.
- The pandemic and the shift in demand to larger-format products appears to have helped the competitive position of the larger firms, which can more easily manage overseas logistics and upgrade equipment, and have other cost and sales advantages.



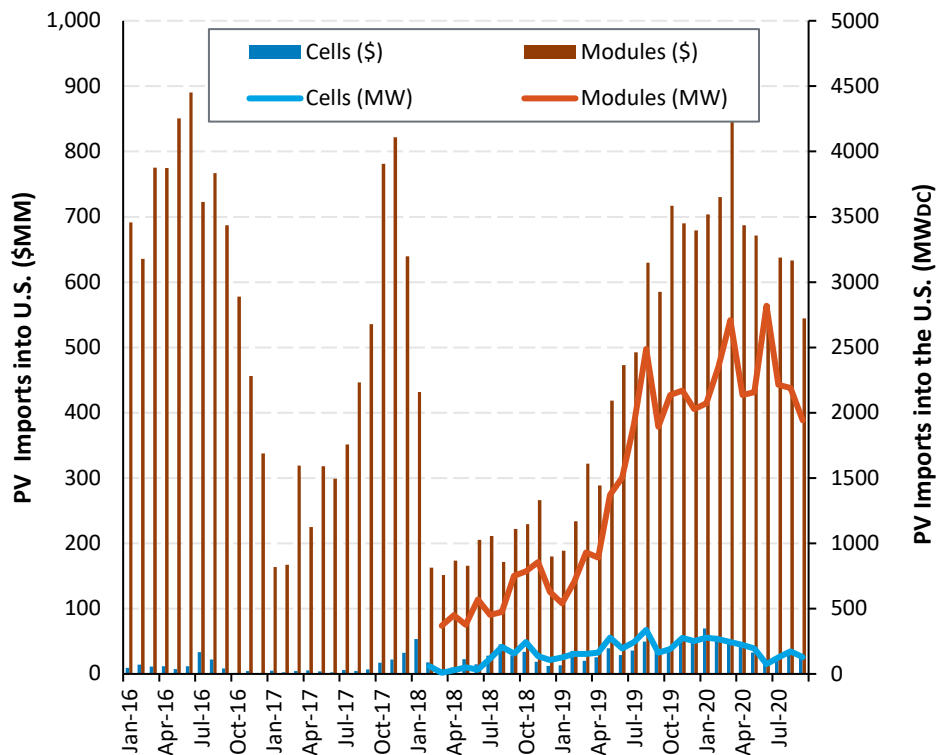
# PV Manufacturers' Margins



- The median gross margin of the publicly traded PV companies represented to the left increased in Q3 2020; margins are at relatively high levels historically.
- There continues to be significant variation by individual companies as individual factors come into play.

Lines represent the median, with error bars representing 80<sup>th</sup> and 20<sup>th</sup> percentiles for the following companies in Q3 2020: Canadian Solar, First Solar, LONGi, Motech Industries, Tongwei, Maxeon, Risen, Shanghai Aerospace, Trina Solar, and United Renewable Energy. Margin data from Hanwha Q Cells, Jinko Solar, JA Solar, Renesola, Sunpower, and Yingli are also included from Q1 2010 to Q1 2020 where available.

# Module and Cell Import Data



- Despite tariffs, PV modules were imported at historically high levels in the first 9 months of 2020.

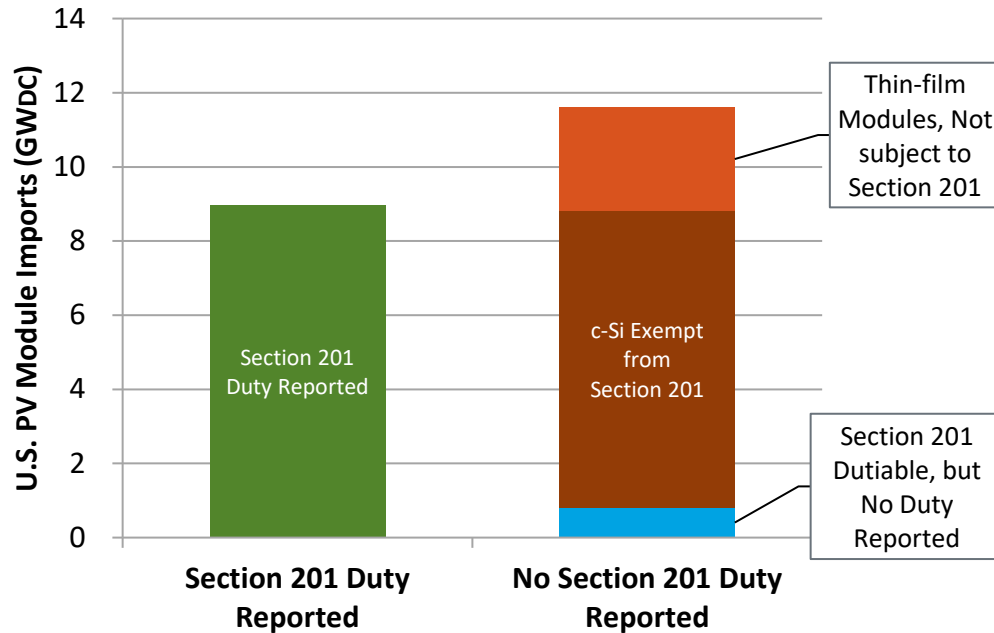
- 20.6 GWDC of PV modules were imported Q1–Q3 2020.
- 1.7 GWDC of cells were imported Q1–Q3 2020.
- Starting February 7, 2020, Section 201 tariffs dropped from 25% to 20%, although additional tariffs still exist for Chinese products.

- In addition to imports, First Solar’s 1.9-GWDC Ohio manufacturing facility averaged over 100% capacity utilization in Q2 and Q3 2020.

- With 5.5 GWDC of annual c-Si PV module assembly capacity, 1.7 GWDC of imported cells in the first 9 months of 2020 implies a 42% utilization rate.

- The actual utilization rate may be slightly higher because of the domestic production of cells and the drawing down of inventory.

# Q1–Q3 2020 U.S. Module Imports by Tariff



- In the first 9 months of 2020, 11.6 GW<sub>DC</sub> of imported PV modules did not report a tariff.
  - Historically, most of these modules have been thin-film, but in the first 9 months of 2020, most of them (8.0 GW) were reported to be c-Si and exempt from the Section 201 duties—largely from South Korea, Vietnam, Thailand, and Malaysia.
    - Most of these were likely bifacial modules, which were exempt from duties for most of 2020, despite legal challenges. However, in November 2020 the U.S. Court of International Trade reinstated the tariffs.
  - For approximately 0.8 GW of imported c-Si modules—subject to Section 201—no duties were reported. Why this happened is unclear.

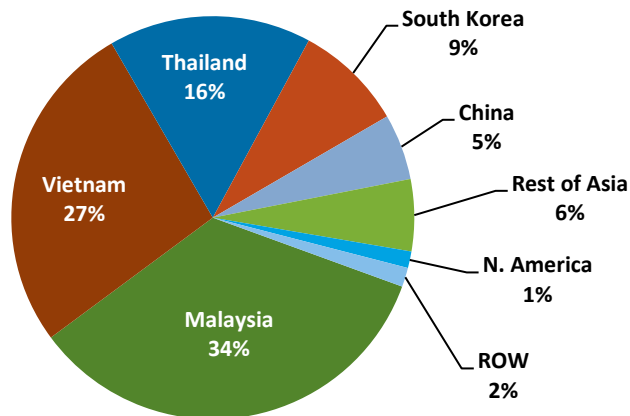
**Note:** Module data uses codes: 8541406015, 8541406020, 8541406035. We assume all modules not subject to Section 201 tariffs are reported under “Free under HS Chapters 1-98” or “Entered into U.S. Virgin Islands,” with exemptions coming from HTS code 8541406015, and technologies not applicable reported under HTS code 854140603. We assume all panels subject to Section 201 duties have been reported under “Dutiable- HS chapter 99.”

Source: Imports, by MW: U.S. International Trade Commission, 2020.

# Module and Cell Imports by Region

- From Q1-Q3 2020, most PV modules and cells were imported from Asia.
  - Cell imports concentrated in fewer countries due to the cell manufacturing locations of companies with U.S. module assembly capacity (e.g., Hanwha and LG [South Korea]; China Sunergy, Seraphim Solar, and Jinko Solar [China]).

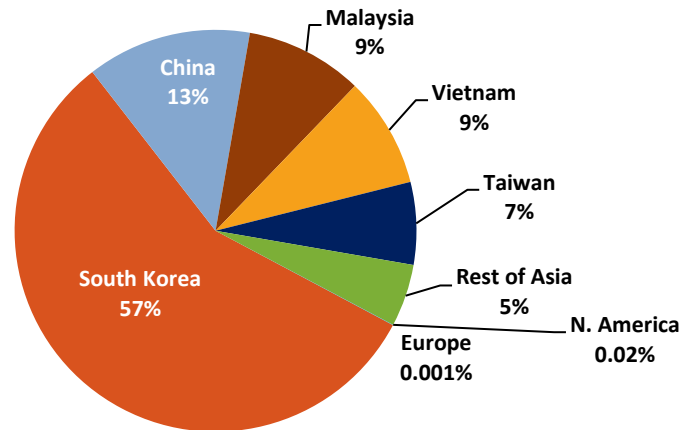
**Q1-Q3 2020 U.S. Module Imports by Region (20.6 GWDC)**



**Note:** Cell data uses HTS codes: 8541406030, 8541406025; module data uses codes: 8541406015, 8541406020, 8541406035  
Sources: Imports, by value and MW: U.S. International Trade Commission, 2020.

- In October, the United States initiated a Section 301 investigation of Vietnam for currency manipulation.
  - From Q1 to Q3 2020, 27% of imported PV modules (over 5 GWDC) and 9% of imported PV cells came from Vietnam.
  - Under Section 301, there are 25% tariffs on a wide range of Chinese goods, including PV modules and cells.
- If Vietnam is found to be in violation, the United States could impose tariffs as soon as January, shortly before the 2020 inauguration.

**Q1-Q3 2020 U.S. Cell Imports by Region (1.7 GWDC)**

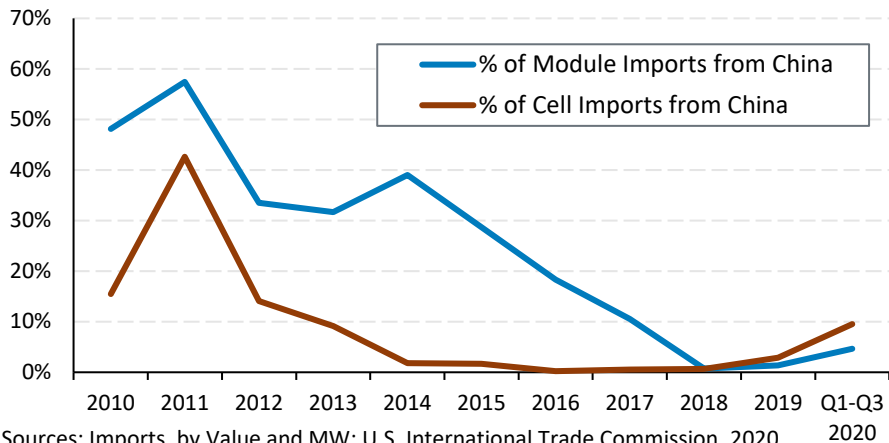


# Chinese PV Imports

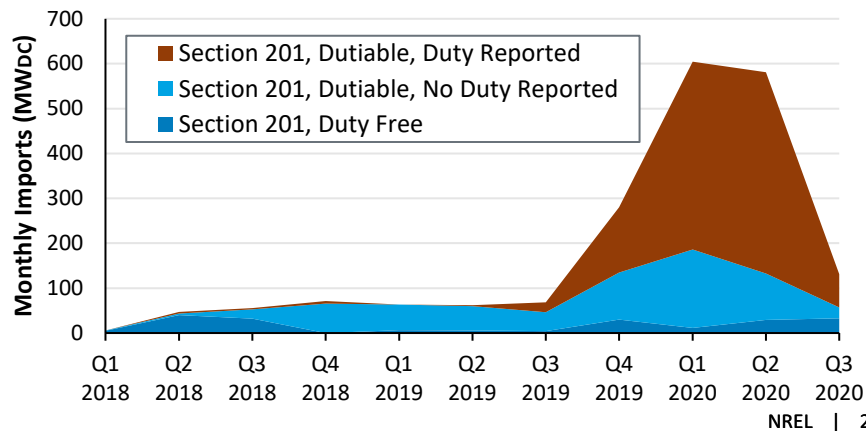
- Until late 2019, Chinese PV imports into the United States had decreased steadily over the decade.
  - Chinese PV cell imports fell first with tariffs introduced in 2012, and these were followed by subsequent module tariffs in 2014.

- From Q3 2019 to Q2 2020, U.S. module and cell imports from China increased dramatically.
  - The Section 201 bifacial exemption was enacted in June 2019 before imports took off.
    - China has a significant bifacial PV manufacturing capacity.
- From Q2 to Q3 2020, U.S. imports of Chinese PV modules and cells dropped precipitously, falling from 8% of total imports to 2%—before the removal of the bifacial exemption.

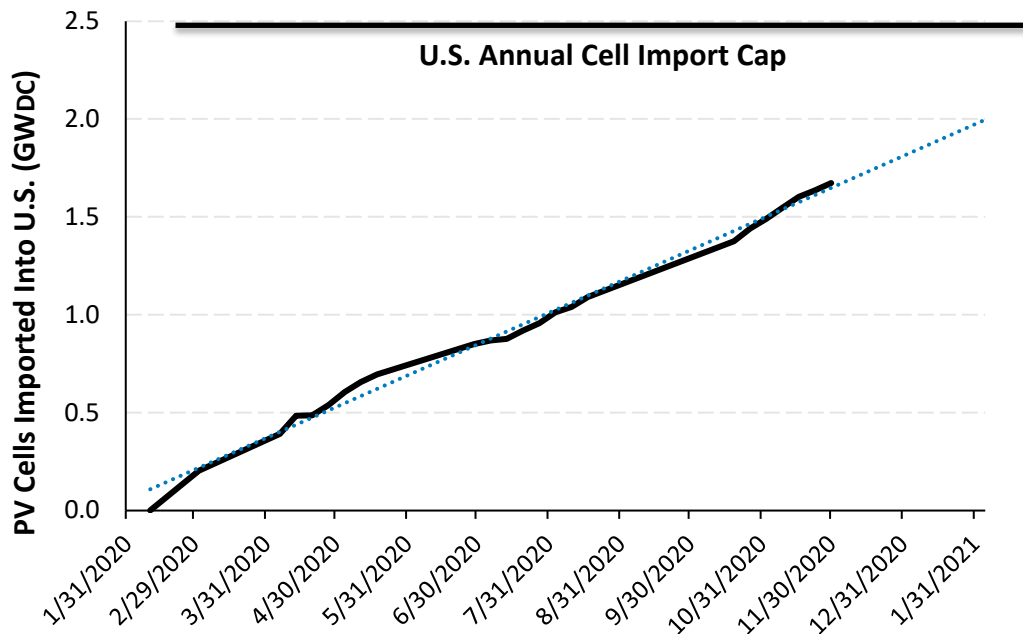
Percentage of U.S. PV Imports from China



Monthly Module and Cell Imports from China



# Cell Import Data by Tariff



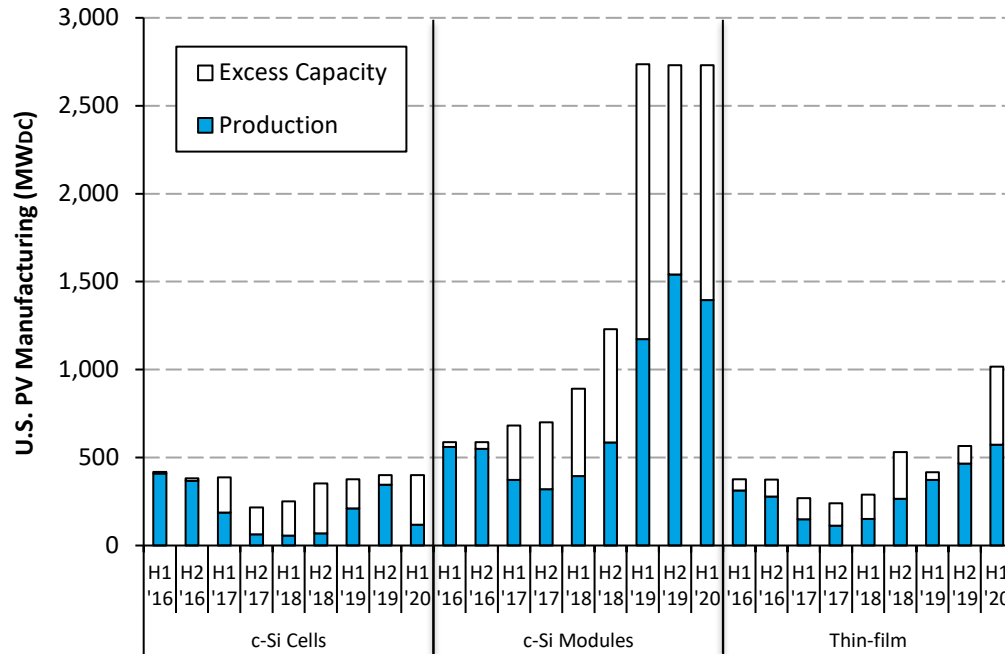
**Note:** Cell data uses HTS codes 8541406025.

Sources: Imports, by MW: U.S. International Trade Commission, 2020; U.S. Customs and Protection Commodity Status Reports.

A 2.5-GW<sub>DC</sub> quota (February 7, 2020–February 6, 2021) exempts the first 2.5 GW of imported c-Si PV cells, subject to the Section 201 tariff.

- In the previous period, the United States came close to, but did not exceed the 2.5 GW PV cell quota.
- As of November 30, 2020, 1.7 GW of cells—or 67% of the total allowable to be exempted—fell under the quota.
- If the February–November 2020 trend continues through the remainder of the period, the United States would not exceed the 2.5 GW by February 2021; however, the slowdown in cell imports may be related to the pandemic.

# U.S. Module and Cell Manufacturing



Source: Wood Mackenzie Power and Renewables/SEIA: [U.S. Solar Market Insight Q3 2020](#) and previous U.S. Solar Market Insight reports.

- In H1 2020, U.S. c-Si module production dipped 9% from the historical high it reached in H2 2019, because of pandemic-related factors.
  - Though manufacturing was mostly categorized as an “essential business,” there were international shipping-related logistical issues, and many manufacturers took actions to reduce the potential for virus outbreaks.
  - In the first half of 2020, U.S. c-Si cell production was still up 19%, y/y.
- Despite pandemic-related issues, thin-film manufacturer First Solar grew production 31% and doubled capacity from H2 2019 to H1 2020, as part of its larger effort to increase its global manufacturing capacity.
- In H1 2020, U.S. PV cell production decreased 66% from H2 2019, and virtually no panels were produced in Q2 2020.
  - Panasonic halted cell production for 2 months because of pandemic-related concerns. It also planned to fully stop production in Q3 2020.

# Current Tariffs (and Shipping Costs) on Imported Modules to the United States

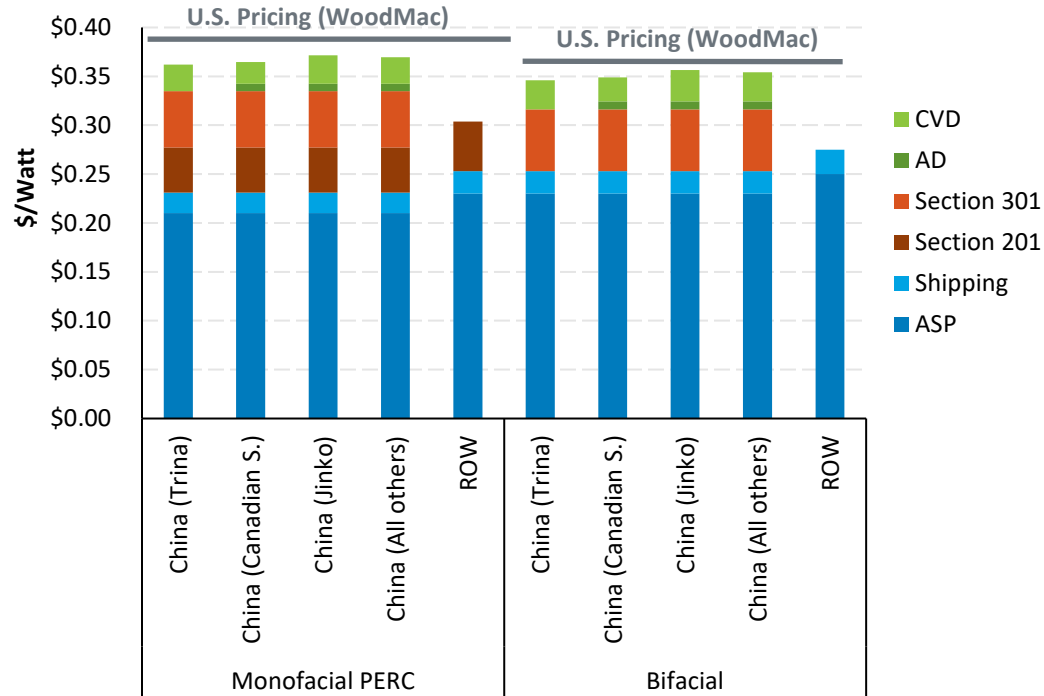
	Monofacial PERC					Bifacial				
	China (Trina)	China (Canadian Solar)	China (Jinko)	China (All others)	ROW	China (Trina)	China (Canadian Solar)	China (Jinko)	China (All others)	ROW
<b>Shipping &amp; Handling</b>	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
Section 201	20%	20%	20%	20%	20%					
Section 301	25%	25%	25%	25%		25%	25%	25%	25%	
AD	0%	3.19%	3.19%	3.19%		0%	3.19%	3.19%	3.19%	
CVD	11.76%	9.70%	12.70%	11.76%		11.76%	9.70%	12.70%	11.76%	
<b>Combined Tariffs</b>	<b>57%</b>	<b>58%</b>	<b>61%</b>	<b>60%</b>	<b>20%</b>	<b>37%</b>	<b>38%</b>	<b>41%</b>	<b>40%</b>	<b>0%</b>

- Shipping costs have dropped recently, but they still can add 10% to the factory-gate prices.
- On top of module factory-gate plus shipping costs, the United States has imposed tariffs as high as 61% for monofacial modules from China, though this is down to 20% from most other countries\* (down from 30% two years ago).
  - The current bifacial exemption from Section 201 tariffs cuts 20% off combined tariff rates for all bifacial modules entering the United States.

\*Note: Taiwan excluded from this analysis

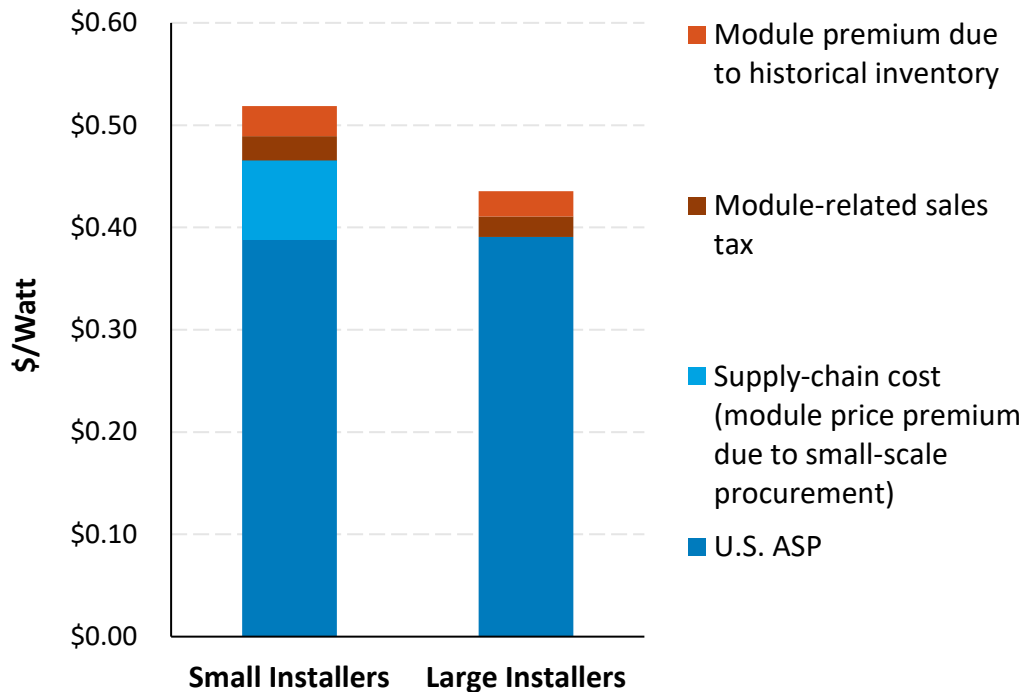


# Tariff Impact on U.S. Module Pricing, Q2 2020



- In Q2 2020, Wood Mackenzie reported an average U.S. monofacial mono c-Si PERC module price of \$0.39/W and a bifacial price of \$0.36/W.
  - Global ASP during that time was reported to be \$0.15/W-\$0.20/W lower.
- The various tariffs and shipping can add \$0.03/W to \$0.16/W.
  - Other friction, supply/demand imbalances, or buyer characteristics, likely make up the gap between the bottom-up cost analysis and Wood Mackenzie’s reported numbers.

# Additional U.S. Module Related Costs: Residential



- Beyond shipping and tariff costs, U.S. buyers incur additional costs that can push final prices from a \$0.2/W global price to above \$0.5/W final price.
  - Many residential installers have historical module inventories they are carrying, with costs that often exceed current levels.
  - Smaller installers typically incur a price premium, often via purchases through wholesalers.
  - Many, though not all, states have sales tax.

# PV Shipment Rankings

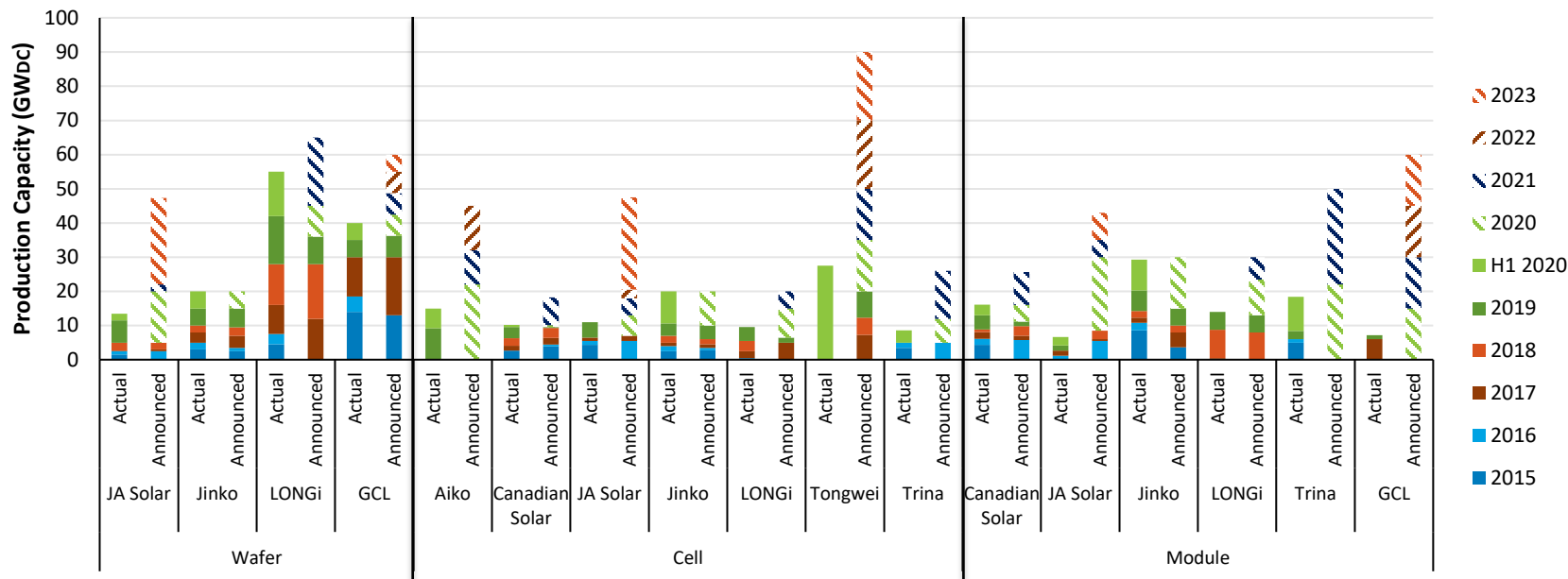
Rank	H1 2020 Shipments	
	Cells	Modules
1	Tongwei (10 GW-20 GWDC)*	Jinko Solar (7.9 GWDC)
2	Aiko (4 GW-6 GW)*	LONGi (~7 GW)
3	Runergy (3 GW-5 GW)*	Trina Solar (~5 GW)
4	ShanXi Lu'An (2.5 GW)*	JA Solar (~5 GW)
5	Solar Space	Canadian Solar (5.1 GW)
6		Hanwha Q Cells
7		Risen Energy
8		First Solar (2.5 GW)
9		Chint (Astronergy)
10		Suntech

***\*Estimates based on reported capacity***

- PV InfoLink attributed the pandemic and the shift to larger format products to the dramatic increase in dominance of large Chinese manufacturers.
  - Large companies could more easily upgrade to large format products and secured overseas logistics channels.
  - The top 10 companies shipped approximately 85% of global module in H1 2020, compared to 60%–70% over the past few years.
- The largest cell manufacturers also grew in market share in H1 2020 because of cost and sales advantages, and compatibility with larger wafers.
  - The top five companies significantly grew PV cell shipment in H1 2020, with Tongwei, Aiko, and Runergy's shipments growing 31%, 83%, and 100%, respectively, compared to H1 2019.
  - With new PV cell capacity coming online in H2 2020 as well, PV InfoLink believes many older cell fab lines may be eliminated.

# Manufacturing Expansion by Leading Suppliers

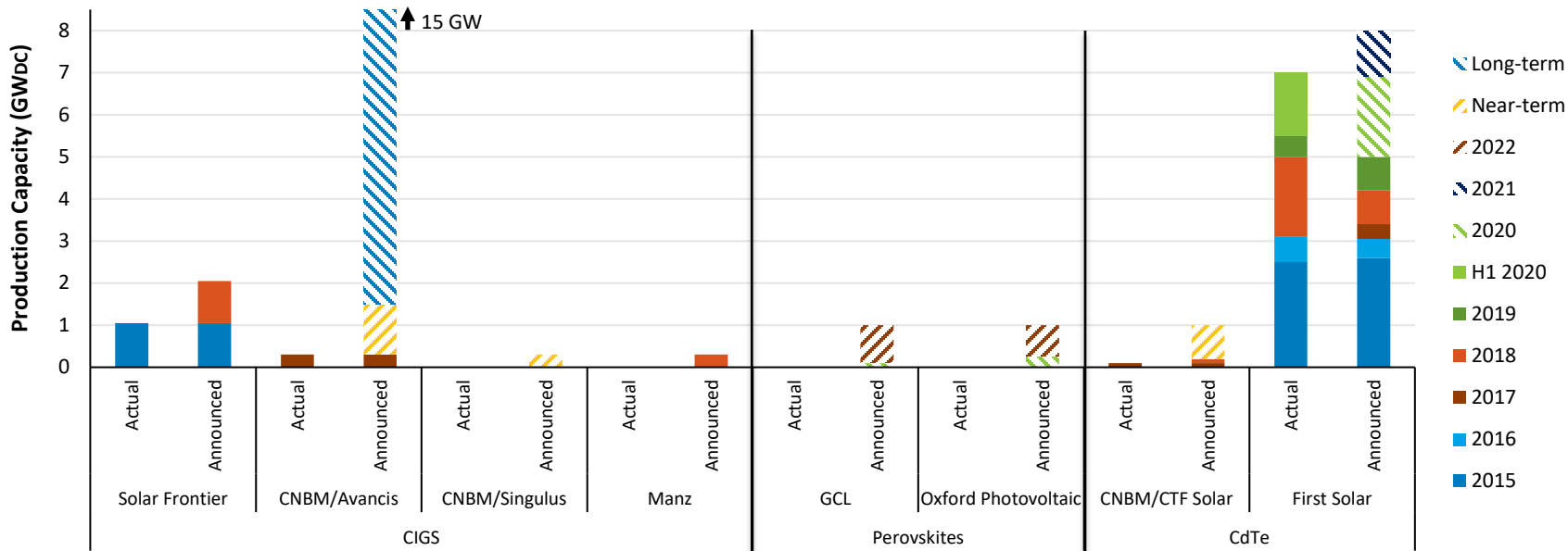
- In 2019 and 2020, some of the leading PV manufacturers announced significant manufacturing expansion plans throughout the supply chain, increasing capacity by 1–9X.
  - The minimum threshold for many of these commitments are 20 GWDC, with several being 2-5X that size.
- In recent history, these companies have made increased capacity announcements of similar orders of magnitude increases, and they have generally achieved their goals.



# Manufacturing Expansion by Leading *Thin-Film* Suppliers

- Several thin-film manufacturers have announced major manufacturing expansions of non-c-Si based technology.
  - Except for First Solar, these plans have not yet come to fruition

- Several European-based manufacturers partnered with large Chinese companies to significantly expand CIGS and CdTe production.
  - While these partnerships have resulted in the construction of pilot plants, they have not yet moved to the next phase of rapid scale-up.
- CIGS in particular is finding more success in nontraditional applications, such as BIPV.





## 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 Activity

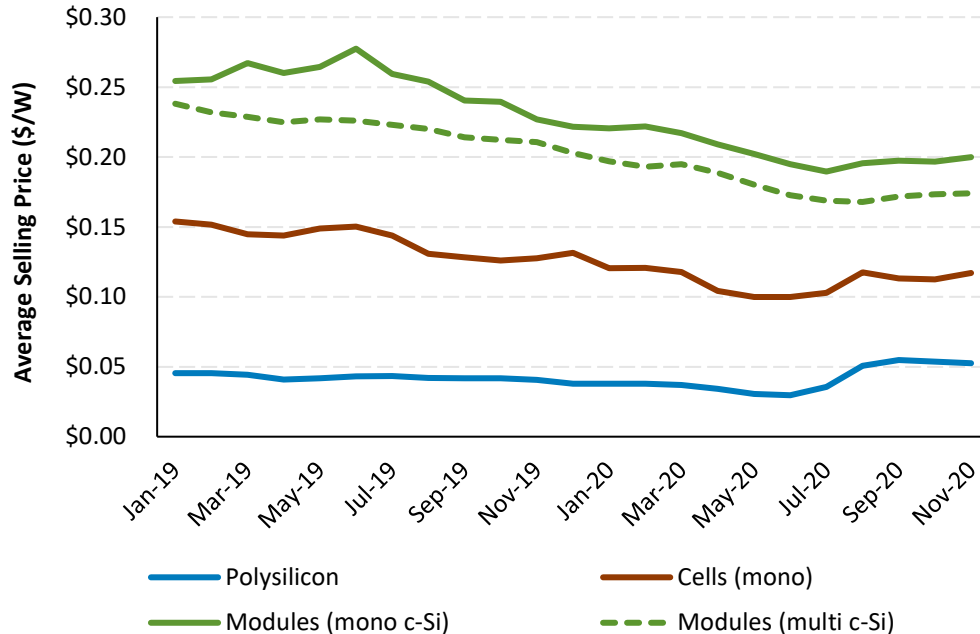
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## Global Soft Costs Trends

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- **Significant disruptions in the polysilicon industry over the summer affected pricing throughout the supply chain. Prices have stabilized since then, holding relatively flat.**
- **Even with supply-chain disruptions, BNEF reported global mono c-Si module pricing around \$0.20/W and multi c-Si module pricing around \$0.17/W.**
- **In Q2 2020, U.S. mono c-Si module prices fell, dropping to their lowest recorded level, but they were still trading at a 77% premium over global ASP.**

# PV Value Chain Spot Pricing

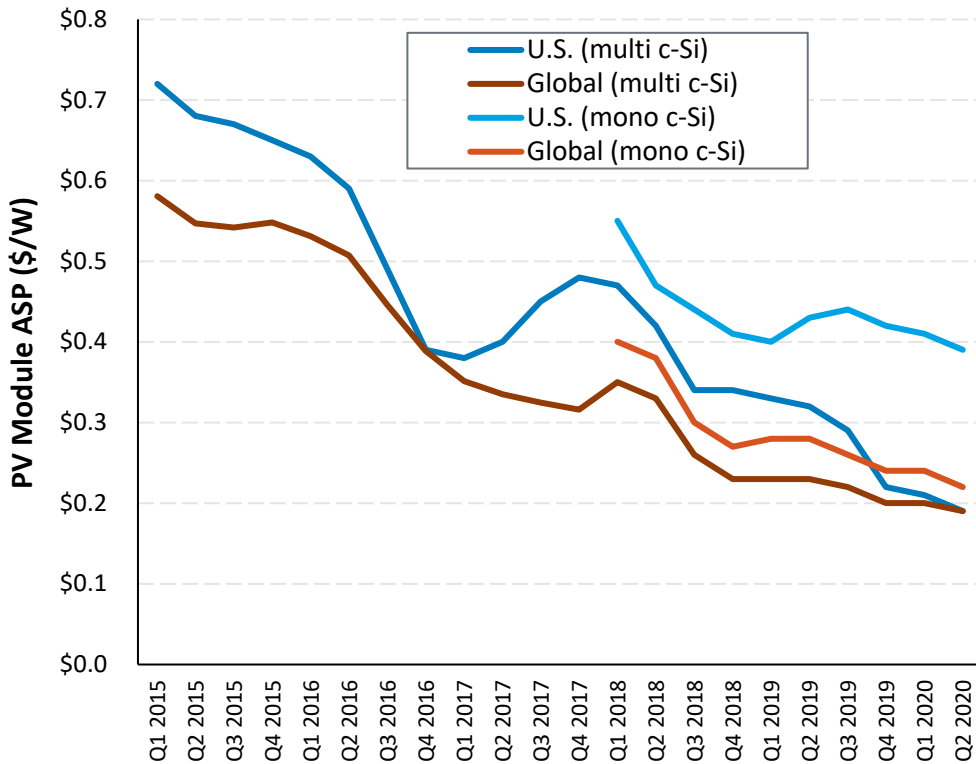


- Supply disruptions in the polysilicon industry caused PV module and component prices to increase in July and August 2020, but they mostly stabilized from September through November.
- Even with the supply-chain price increases, BNEF reported global mono c-Si module pricing below \$0.20/W and multi c-Si module pricing below \$0.17/W.
  - BNEF began reporting price differences based on wafer/cell sizes, which vary 2–3 ¢/W between 158.75-mm and 210-mm cells.

Source: BNEF Solar Spot Price Index (12/03/20).

Kilogram to watt conversion: 4.78 grams per watt (2016); 4.73 grams per watt (2017, 2018, 2019, 2020), from Cowen & Co. (05/11/17); Deutsche Bank (07/19/17).

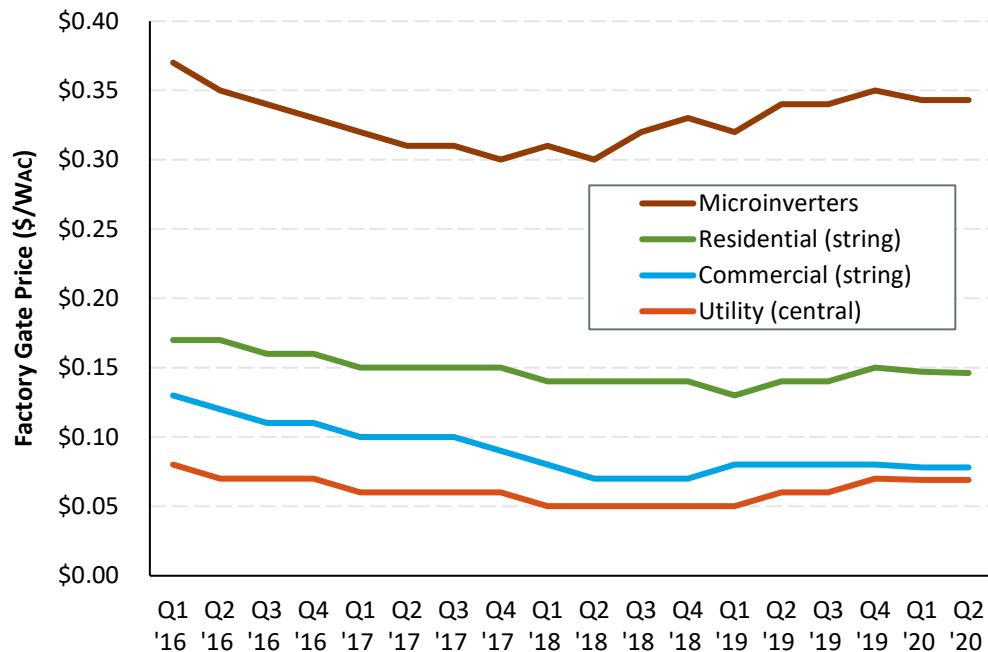
# Module Average Selling Price: Global versus United States



- In Q2 2020, U.S. mono c-Si module prices fell, dropping to their lowest recorded level, but they were still trading at a 77% premium over global ASP.
  - U.S. multi c-Si module prices dropped precipitously because of a significant lack of demand, to global pricing.
  - Bifacial modules were trading a few cents below mono c-Si in the United States because of a temporary injunction on the Section 201 tariffs; however, they are likely to increase after the U.S. International Trade Court removed the exemption.



# Inverter Pricing



- After tariffs were imposed on Chinese-made inverters, prices increased in 2019 and many manufacturers focused on diversifying their supply chains.
  - Due to this diversification, the U.S. inverter supply chain was less affected by the pandemic outbreak in China.
  - Inverter pricing remained relatively flat in H1 2020.



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 Activity**

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Global Soft Costs Trends

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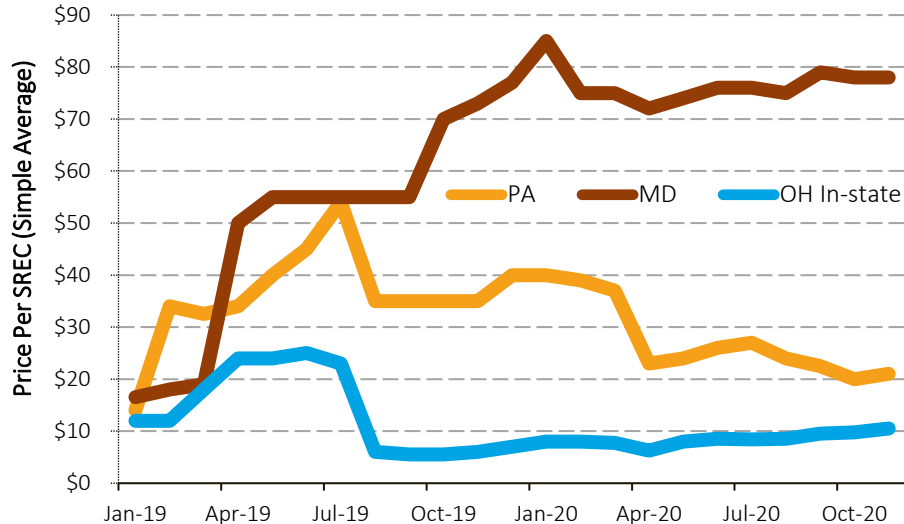
- Despite the pandemic's effect on electricity sales (a driver of SREC demand) and PV deployment (a driver of SREC supply), SREC markets have been relatively flat thus far in 2020.
- **Although solar stock gains made in the beginning of 2020 were erased with the downturn in the market in March, they have significantly outperformed the rest of the market since then.**
  - Analysts attribute these gains to good financial performance from companies, driven by stronger than expected global demand, despite the pandemic.

# SREC Pricing

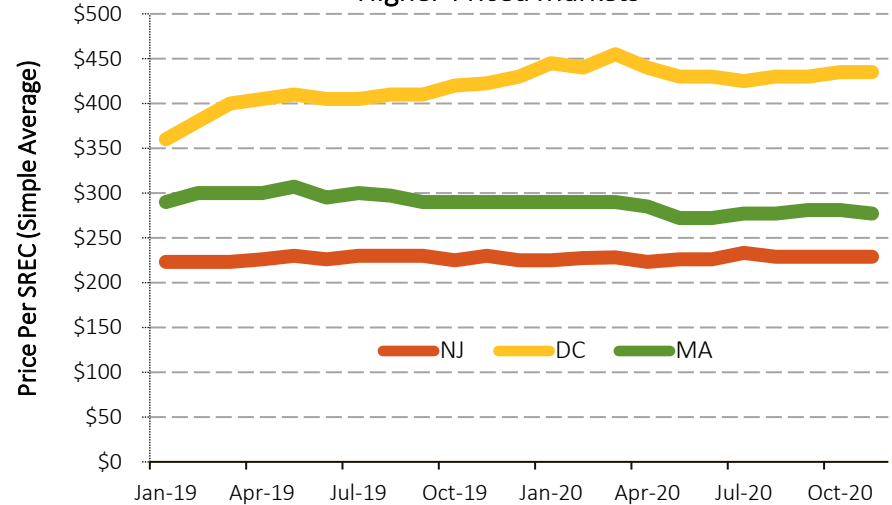
- Despite the pandemic's effect on electricity sales (a driver of SREC demand) and PV deployment (a driver of SREC supply), SREC markets have been relatively flat thus far in 2020.
  - SRECTrade estimates DC has an oversupply of SRECs in 2020, but pricing has been relatively flat, y/y.

- In April 2020, Virginia passed a mandatory RPS, with a 1% carve-out for in-state solar facilities. It is unknown whether SREC trading, or a central procurement program, will be established in 2021; however, the solar alternative compliance payment is set at \$75.
- New Jersey and Massachusetts have moved away from offering SRECs to new projects in recent years, in lieu of fixed payments.

### Lower-Priced Markets

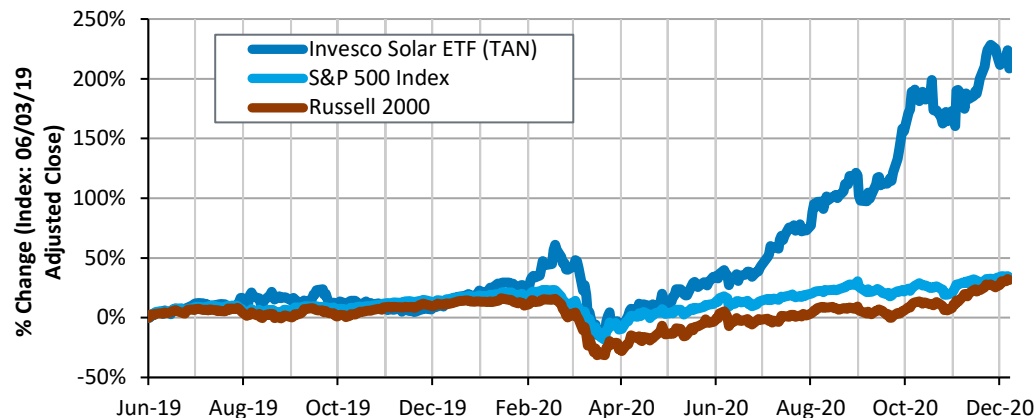


### Higher-Priced Markets



# Stock Market Activity

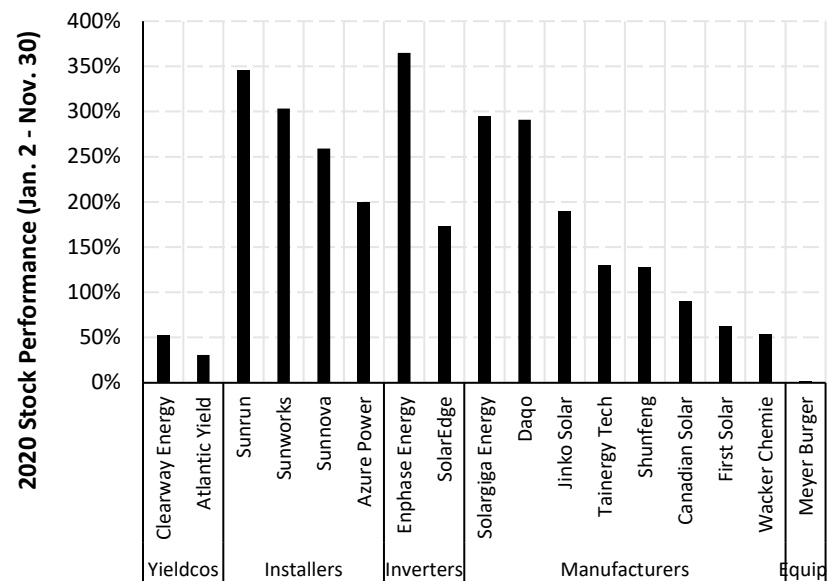
- Although solar stock gains made in the beginning of 2020 were erased with the downturn in the market in March, they have significantly outperformed the rest of the market since then.
  - Analysts attribute these gains to good financial performance from companies, driven by stronger than expected global demand, despite the pandemic.
  - Compared to 10 years ago, the TAN index is virtually flat, while the S&P and Russell index are up over 1.5X.



Source: Stock market: Yahoo Finance (12/09/20).

- Not all sectors or companies fared the same, but there was fairly strong growth across most sectors.

## 2020 YTD Performance



**Note:** The TAN index is weighted toward particular countries and sectors. As of 08/31/20, 52% of its funds were in U.S. companies. Its top 10 holdings, representing 63% of its value, were Sunrun, SolarEdge, Enphase, First Solar, Xinyi, Vivint Solar, Daqo, SunPower, Solaria Energia, and Encavis.



- 1 Global Solar Deployment

- 2 U.S. PV Deployment

- 3 PV System Pricing

- 4 Global Manufacturing

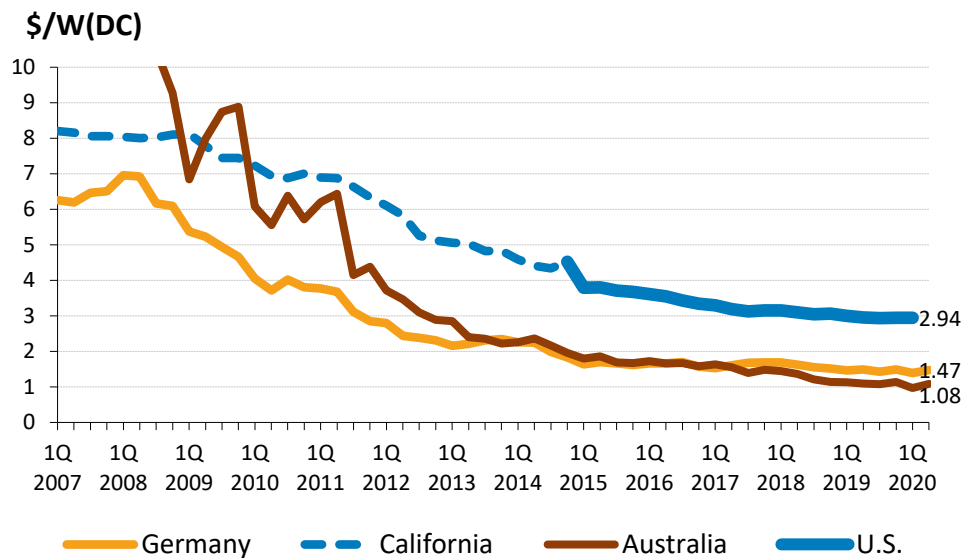
- 5 Component Pricing

- 6 Market Activity

- Global Soft Costs Trends**

**Despite large volumes of residential PV deployment in the U.S., its prices have remained significantly higher than other large markets, including Germany and Australia.**

# Residential PV System Pricing



- Despite large volumes of residential PV deployment in the United States, its prices have remained significantly higher than other large markets, including Germany and Australia.
- Price premium has been attributed to multiple factors:
  - Nonuniform, spread-out U.S. marketplace
  - Differences in policy and financing support
  - Permitting and regulatory hurdles
  - Tariffs
  - Inefficient labor practices

*Historically, lower prices in Germany were partly explained by having larger systems (which benefited from economies of scale); however, U.S. systems are now, on average larger than German and Australian residential systems.*

# Policy Support and Financing

## Australia

- **Policy:** In addition to some favorable state incentives, Australia’s national Small-scale Renewable Energy Scheme (SRES) credits customers based on the size of their systems; these credits are purchased by large electricity retailers. However, installers usually purchase the certificates from their customers upfront and system prices are typically advertised (not reported) post-subsidy. Australia also offers net (or in some cases gross) metering.
- **Financing:** Most residential customers purchase PV systems using cash or a mortgage extension, with rates between 4.3% and 5.5%.

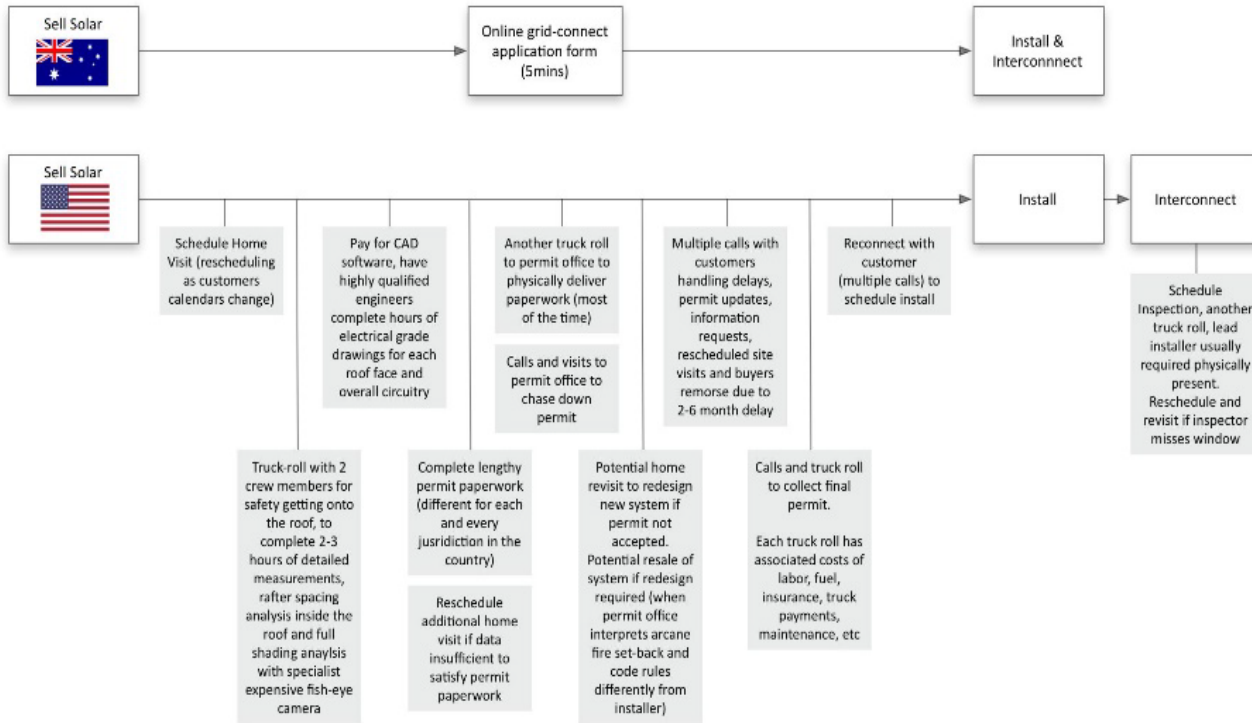
## Germany

- **Policy:** Germany has historically offered a national feed-in-tariff to residential consumers, guaranteed for 20 years. The FIT offering goes down over time, based on deployment, and it is currently below retail rates. Because of this, many customers are designing systems for self consumption.
- **Financing:** The government-owned development bank KfW(Kreditanstalt für Wiederaufbau, or Reconstruction Credit Institute) offers—under certain conditions—a loan interest rate of 1%. Other banks offer loans at higher rates.

## United States

- **Policy:** The United States offers a national tax credit, which is received after taxes are filed and depends on customers’ income levels. Many locations also depend on state-level incentives or measures, which vary widely in level of benefit and procedure.
- **Financing:** Many national companies offer leases, PPAs, and loans. These are typically based on personal credit, and they can involve complex financial mechanisms to monetize the tax benefits, and a significant amount of overhead. Smaller lenders have offered loans of 6%–7%; however, larger loan providers typically reduce their APR (which may start out at 10%) by offering a fee of 2%–4% of the value of the loan for 1% APR reduction.

# Permitting, Interconnection, and Inspection (PII)



- In Australia, no permit is required—only a simple online interconnection request. Inspection for rebates is provided by the government.
- In Germany, many standards are set at the national level and many local jurisdictions have exempted PV from building permitting. Interconnection, which is governed by the European Union, involves an on-line application, utility review, and commissioning, but no contract is required, and Germany requires that utilities prioritize renewables for interconnection.
- In the United States, PII varies dramatically by local, utility, and state jurisdiction, and it can take many months.
- NREL benchmarks average residential U.S. PII costs to be \$0.24/W, compared to estimates of \$0.01–\$0.05/W in Australia and Germany.

Sources: O’Shaughnessy et al. 2019. “Addressing the soft cost challenge in U.S. small-scale solar PV system pricing.” GTM, “[How to Halve the Cost of Residential Solar in the US.](#)” RMI, “[Lessons from Australia Reducing Solar PV Costs Through Installation Labor Efficiency.](#)” [Streamlining Photovoltaic Deployment: The Role of Local Governments in Reducing Soft Costs](#); NREL, “[Comparing Germany’s and California’s Interconnection Processes for PV Systems.](#)”

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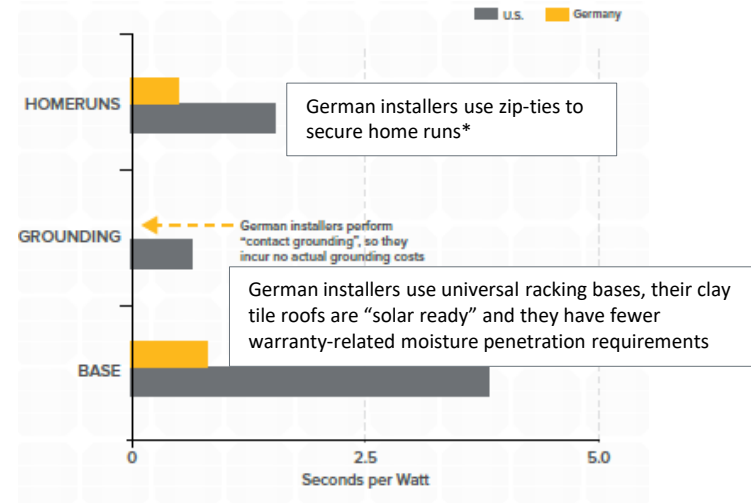
# Impact of Regulatory Code on Labor and Material

- Australia has a voluntary code of conduct, where the onus is on the consumer to choose the best installer.
  - Australian installations often have fewer grounding points, and fewer meters as well.
  - Total installation time in Australia is estimated to be 6.1 hours compared to 9.4 hours in the United States. There is a big difference in cost for systems installed in a day or less compared to those which take multiple days.
- Germany also has fewer code requirements than the United States. For example, German installers face significantly less onerous grounding requirements. Though they still ground systems, they do so in a way that does not require additional wiring.
- The U.S. National Electric Code dictates best practices (though it is a regionally adopted standards).
  - Some have claimed no noticeable difference in quality and safety between overseas systems and U.S. systems.

\* A “home run” is an electrical cable that carries power from a solar panel to the combiner box.

Sources: Wood Mackenzie, [“How to Halve the Cost of Residential Solar in the US.”](#) RMI [Lessons From Australia - Reducing Solar PV Costs Through Installation Labor Efficiency](#)

USA	Australia
Metal Conduit Runs requiring bending and shaping on roof (to exact position as laid out in permit), then often painting	Rubber conduit tacked to walls
Up to 4 disconnect boxes, depending on local rules, each needs wiring, placement and additional metal conduit	No separate disconnects
Remote disconnect technology (incremental hardware cost and installation time and expense)	No remote disconnect
Need to tie to detailed permit drawing to get approval to interconnect - requires install attachments to rafters at exact spacing and need to obey complex rules on breaker placement	No electrical grade fixed design - freedom to make smart decisions on site

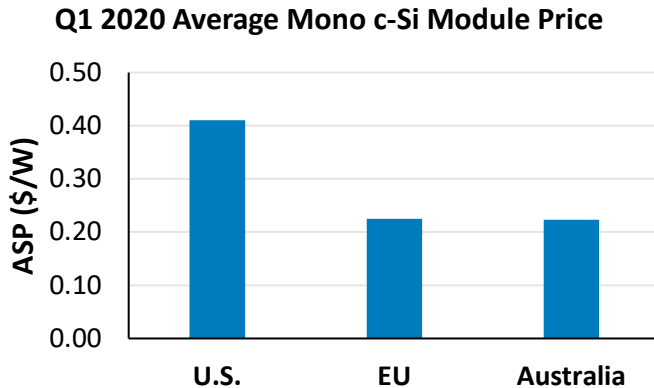


# Impact of Better Business Practices on Labor

- Some studies point to better, more-efficient business practices in Australia and Germany than the United States. These include:
  - Highly specialized roles and simplified processes and components
    - » Contractors prepare at the warehouse more quickly because vans are stocked with universal equipment.
    - » Modules are prepped before getting on-site.
    - » Bases self seal and have minimal penetration so there is no need for flashing, etc.
  - More efficient racking design (e.g., rail-less racking)
  - Simpler electrical and component design that is due in part to less stringent regulatory codes.
  - One-day builds.
- Some of these solutions have already been instituted in the United States since the studies came out, and others are inhibited by code.

# Tariffs

- In Q1 2020, BNEF reported that the average selling price of modules in the United States was approximately 83% higher than prices in Australia and Europe.
  - These numbers exclude wholesaler markups, taxes, and other friction, which are common to all three residential markets.



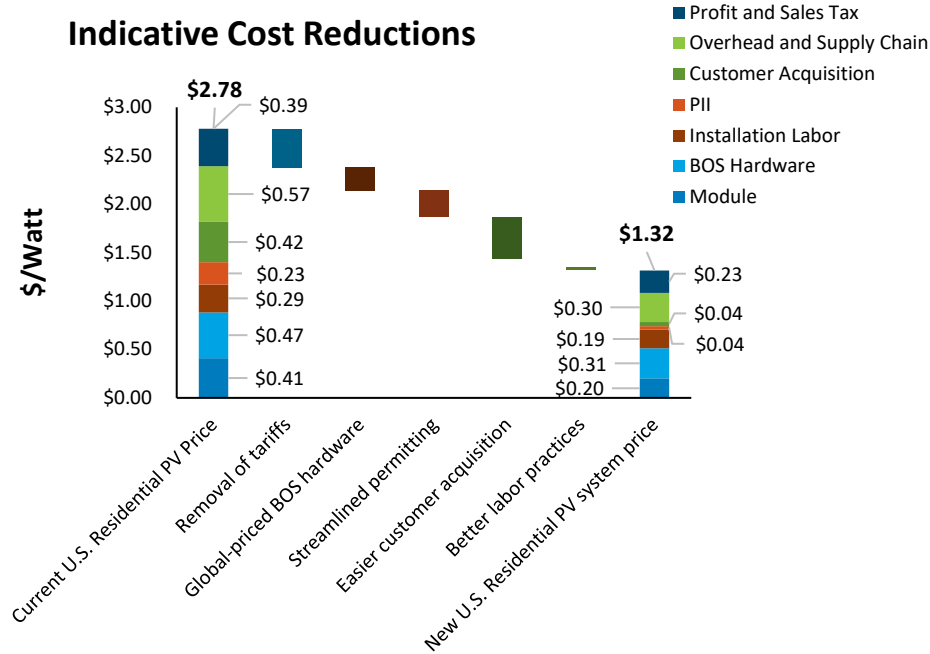
- Most of the price discrepancy can be attributed to several import tariffs the United States has imposed (AD/CVD and Section 301 for Chinese products and Section 201 for most others). Though these U.S. tariffs have gone down over time, U.S. modules are still trading at a significant premium, while customers in Germany (which got rid of most of its tariffs) and Australia can get modules at global averages. Australia may also benefit from lower shipping costs.
- In addition to tariffs on modules, the United States also has tariffs on Chinese inverters (Section 201), and on steel and aluminum (Sections 232 and 201), which increases U.S. prices over global averages.

# Customer Acquisition

- The CEO of Sungevity estimates that customer acquisition costs in Australia are \$0.08/W (\$400) compared to \$0.50/W (\$2,500) in the United States.
  - Because it is cheaper, faster, and easier to install, it is cheaper, faster, and easier to sell.
- Australia and Germany have much higher levels of solar adoption and the rules there are less regionally specific, so there is a much shorter (if any) education process. There are approximately:
  - 1.8 million PV systems in Germany for a population of 80 million
  - 2.4 million PV systems in Australia for a population of 25 million
  - 2.5 million PV systems for population of 328 million.

The U.S. population is also spread farther apart, while U.S. solar adoption is relatively concentrated, so some areas have much lower penetration levels than average.
- Australia (\$0.14/kWh–\$0.30/kWh) and Germany (\$0.35/kWh) have higher-priced electricity than the United States (\$0.13/kWh), and it is sunnier in Australia, providing better system production, on average.
- Germany and Australia also benefit from low cancelation rates because there are no permit wait times, a more straightforward value proposition (due to national rules, cheaper systems and expensive electricity), and easier financing options.
- U.S. residential PV systems usually involve a bilateral contract on an existing structure, in which the installer seeks out the customer.

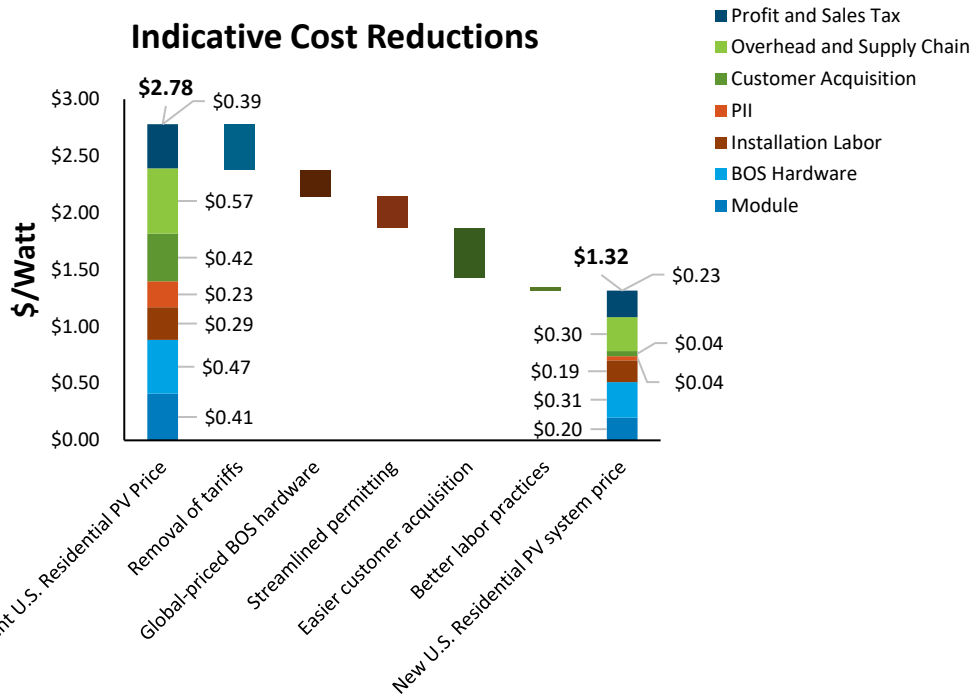
# Potential U.S. Changes



***\*Detailed explanation of reductions are on the next slide.***

1. Replace permits with online applications, a process that has been successfully demonstrated overseas.
2. Remove the unnecessary elements of the NEC code that make no discernable impact on the resulting safety and quality of solar installations, as has also been proven overseas.
3. Adopt better labor practices, such as preassembly, one-day installations, more-efficient mounting, and staging.
4. Remove tariffs from modules and inverters.
5. Policymakers could require utilities or state agencies to host quote platforms or provide information about quote platforms or prevailing local prices to their ratepayers or constituents; this would also allow for platforms to have installer standards.
6. PV could be integrated into other related-service marketplaces (e.g., new builds through building code requirements). Additionally, jurisdictions could offer easier licensing for related-service contractors.
7. Achieve economies of scale through customer aggregation (e.g., solarize).

# Explanation of Cost Reductions



- **Removal of Tariffs:** Module price reduced from \$0.41/W to \$0.20/W. Inverter prices reduced by 10%. Reduced hardware translates to lower supply chain, profit, and sales tax.
- **Global-Priced BOS Hardware:** Use of string inverters only; cheaper racking. Reduced hardware translates to lower supply chain, profit, and sales tax.
- **Streamlined Permitting (and Interconnection):** No permit fees. Online only applications. No schematics. No back and forth between permit office or utility. Zero percent customer attrition due to PII. Lower permitting translates to lower overhead (as fewer staff to manage process and less time spent on government relations) and profit (in absolute terms).
- **Easier Customer Acquisition:** 100% referrals. Less hand-holding. Higher percent of closed sales. Lower customer acquisition translates to lower overhead and profit.
- **Better Labor Practices:** Less prep time, faster racking and wiring, and fewer breaks and cleanup.

**Special thanks to Dan Bilello, Jeff Logan, Mike Meshek, and Madeline Schroeder.**

# Thank You

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# List of Acronyms and Abbreviations

• AC	alternating current	• LBNL	Lawrence Berkeley National Laboratory
• AD	antidumping duty	• kg	kilogram
• APR	annual percentage rate	• kW	kilowatt
• ASP	average selling price	• kWh	kilowatt-hour
• BIPV	building integrated photovoltaic	• MLPE	module-level power electronics
• BNEF	Bloomberg New Energy Finance	• Mono c-Si	monocrystalline
• C&I	commercial and industrial	• Multi c-Si	multicrystalline
• CIGS	Copper indium gallium selenide	• MW	megawatt
• CdTe	cadmium telluride	• MWh	megawatt-hour
• C-Si	crystalline silicon	• NEM	net energy metering
• CSP	concentrating solar power	• PII	permitting, interconnection, inspection
• CVD	countervailing duty	• Poly	polysilicon
• DC	direct current	• PPA	power purchase agreement
• DPV	distributed PV	• PV	photovoltaic
• EIA	U.S. Energy Information Administration	• R&D	research and development
• ETF	exchange traded fund	• ROW	rest of world
• EU	European Union	• Q	quarter
• FERC	Federal Energy Regulatory Commission	• S&P	Standard and Poor's
• G&A	general and administrative expenses	• SEIA	Solar Energy Industries Association
• GW	gigawatt	• SG&A	selling, general and administrative expenses
• H1	first half of year	• SMART	Solar Massachusetts Renewable Target
• H2	second half of year	• SREC	solar renewable energy certificate
• IOU	investor-owned utility	• TAN	Invesco Solar ETF
• ISO	independent system operator	• W	watt
• ISO-NE	ISO – New England	• y/y	year over year
• ITC	investment tax credit	• YTD	year to date