

Q1/Q2 2020 Solar Industry Update

David Feldman
Robert Margolis

September 1, 2020

Executive Summary

- China, the U.S., India, Australia, and Germany collectively installed 24 GW of PV in the first half of 2020, approximately the same level as in 2019.
- Tonopah Solar, the owner of the first large-scale (110 MW) solar tower with molten-salt storage, declared bankruptcy in July 2020, having not operated since April 2019.
- Ten states generated more than 5% of their electricity from solar, with California leading the way at 21.7%.
- Despite possible effects of COVID-19, the United States installed 7.2 GWDC of PV in H1 2020, its largest H1 total ever—up 48% y/y.
- The United States installed approximately 208 MWh (98 MW) of energy storage onto the electric grid in Q1 2020—down 34% y/y.
- In July 2020, Sunrun agreed to purchase Vivint for \$3.2B (in an all stock swap transaction).
- Despite tariffs, PV modules and cells are being imported into the United States at historically high levels, with 14.2 GW of PV modules and 1.3 GW of PV cells in H1 2020.
- First Solar’s 1.9-GW thin-film plant was also operating at a relatively high utilization rate.
- Since late 2019, a growing amount of PV imports into the United States are coming from China, despite continued tariffs.
- Global module and module-component prices continued their declines through June; however, supply disruptions in the polysilicon industry caused PV modules and components to increase in price in July and August 2020. 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.
- In Q4 2019, U.S. mono c-Si module prices fell, dropping close to their lowest recorded level, but they were still trading at a 71% premium over global module average selling price.
- Although solar stock gains made at the beginning of 2020 were erased with the downturn in the market in March, they have significantly outperformed the rest of the market since.
- Analysts attribute these gains to good financial performance from companies, driven by stronger than expected global demand, despite the pandemic.



1 Global Solar Deployment

2 CSP Deployment

3 U.S. PV Deployment

4 PV System Pricing

5 Global Manufacturing

6 Component Pricing

Market Activity

1 Global Solar Deployment

2 CSP Deployment

3 U.S. PV Deployment

4 PV System Pricing

5 Global Manufacturing

6 Component Pricing

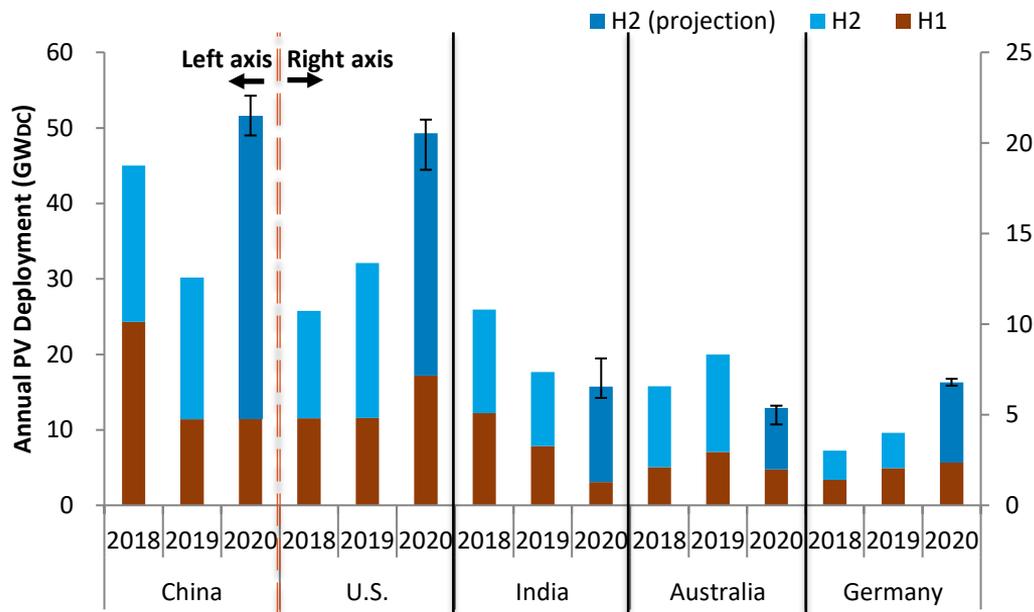
Market Activity

- **China, the United States, India, Australia, and Germany collectively installed 24 GW of PV in the first half of 2020, approximately the same level as in 2019.**
- **Although the pandemic has suppressed 2020 deployment, it has affected countries differently.**
 - **India installed 60% less PV in H1 2020 than in H1 2019, whereas the United States installed 48% more.**
- **BNEF reports approximately 1.6 GW of floating solar in its project database, most of which was installed in China from 2016 through 2019.**
- **GONGLA tracked 8.5 million off-grid solar products, with a capacity of 94 MW, that sold in 2019 for a value of \$565 million.**

H1 2020 Global PV Deployment: Key Markets Update

- These leading five markets collectively installed 24 GW of PV in the first half of 2020, approximately the same level as in 2019.
- While the pandemic has suppressed 2020 deployment, it has affected countries differently.

- India installed 60% less PV in H1 2020 than in H1 2019, whereas the United States installed 48% more.



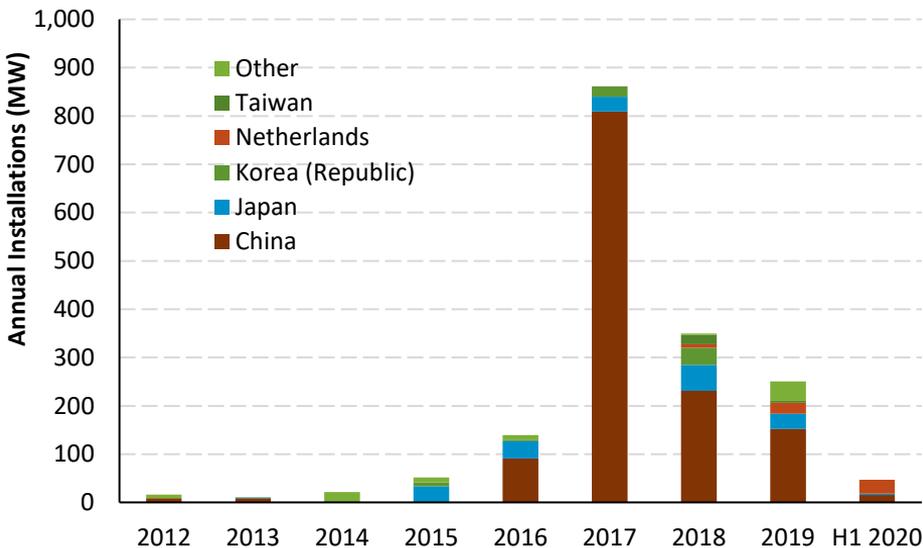
- In Q2 2020, PV construction in India significantly contracted as the coronavirus pandemic disrupted large parts of the economy. Labor availability was cited as the biggest challenge for large installations. Due to the monsoon season in Q3, activity may not pick back up again until Q4 2020.

- Despite the increase, y/y, U.S. PV installations have been affected; 2020 demand expectations before the pandemic were greater than current installation levels.

- In H1 2020, large-scale projects represented 78% of Indian demand, 69% of U.S. demand, 61% of Chinese demand, and 23% of Australian demand. These numbers are consistent with historical trends.

Floating Solar

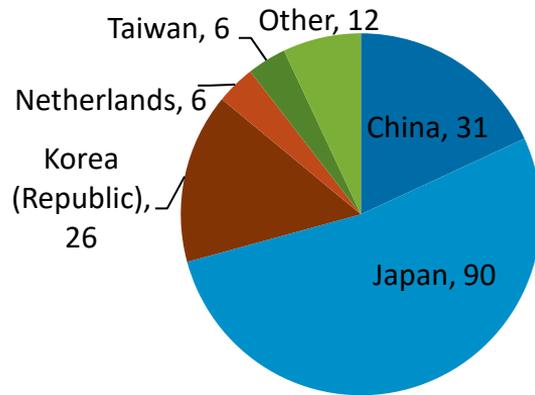
- BNEF reports approximately 1.6 GW of floating solar in its project database, most of which was installed in China from 2016 through 2019.
 - Japanese systems represent more than half of the number of currently installed systems.



Source: BNEF, "Renewable Energy Projects" database. Accessed 08/17/20.

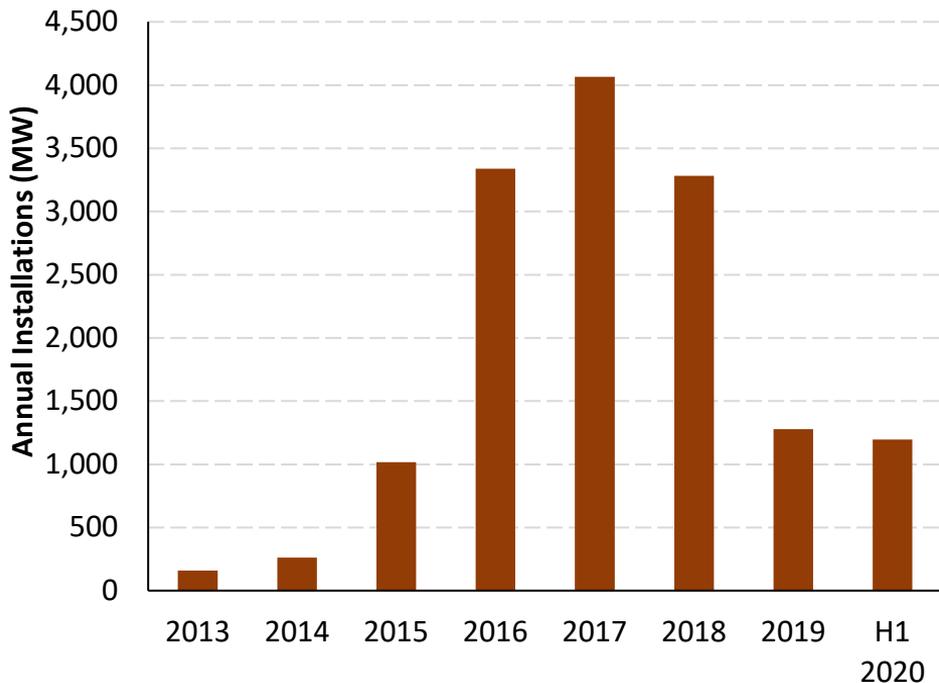
- BNEF reports a robust pipeline of floating solar projects, with 1 GW of projects under construction in 13 countries.
 - There are also 2.9 GW of permitted floating solar projects (2.6 GW of which are in South Korea) and 9.4 GW of announced projects in 22 countries.

of Floating Solar Systems (Cumulative)



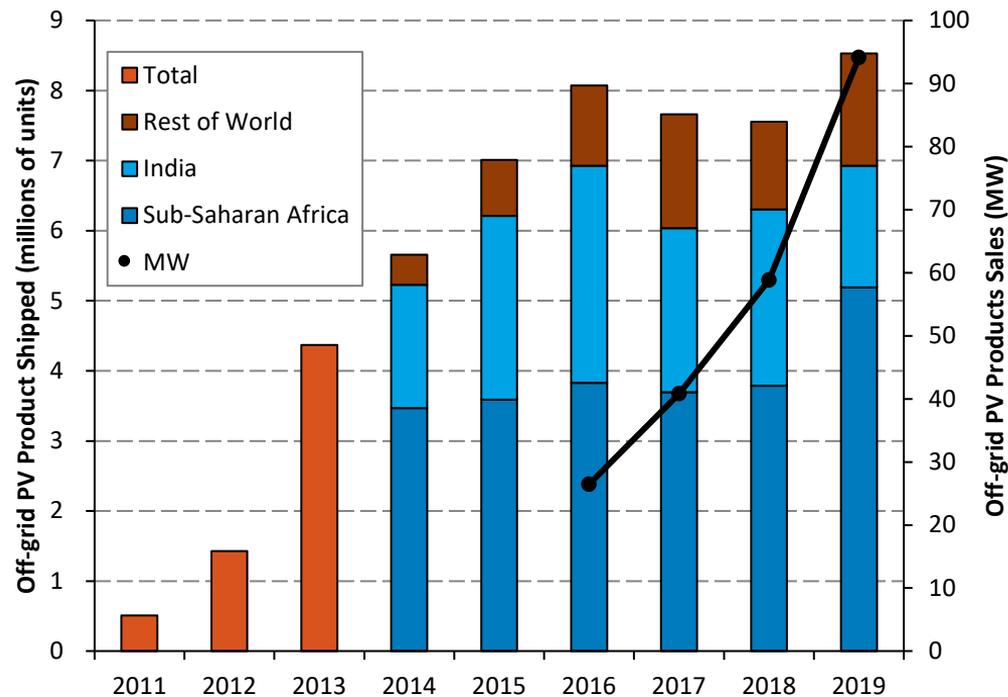
Chinese Fish Farms

Fish Farming PV Installations



- One potential sector in which floating solar could leverage dual use is fish farming. BNEF reports 15 GW of PV systems at fish farming sites, all of which are in China.
 - As of August 2019, fish farms hosted almost 9% of Chinese solar panels.
 - Another 4 GW are under construction, and 27 GW have been announced.
- However, only 200 MW of commissioned fish farms systems are reported to be floating (with another 800 MW in some other stage of development).
 - Instead of floating, PV systems on fish farms may be fixed above or next to the water.
 - There may be more “floating” projects at fish farms that are not labeled as such or not in the BNEF database.

Global Off-Grid Solar Market



GOGLA tracked 8.5 million off-grid solar products, with a capacity of 94 MW, that sold in 2019 for a total of \$565 million.

- GOGLA estimates that it tracks roughly 28% of total off-grid sales, though it varies by product and market.
- 69% of sales in 2019 were in sub-Saharan Africa (half of which were in Kenya and Ethiopia), and 23% were in India.
- Approximately 74% of the systems installed in 2019 were cash sales; however, cash sales only represented 35% of solar home systems (versus the pay-as-you-go financing model).
- GOGLA estimates that the off-grid products sold since July 2010 have improved energy access to more than 313 million people.

Global Off-Grid Solar Market (cont'd.)

Product Size (Watts)	Use	% of 2019 Market Volume	% of 2019 MW Shipped
0–1.5	Single light only	31%	1%
1.5–3	Single light and mobile charging	35%	9%
3–10	Multiple lights and mobile charging	16%	9%
11–20	Solar home system (SHS), entry level (3–4 lights, mobile charging, powering radio, fan, etc.)	18%	80%
21–49	SHS, basic capacity (above plus power for TV and extended capacity)		
50–100	SHS, medium capacity (above but with extended capacities)		
100+	SHS, higher capacity (above but with extended capacities)		

- In 2019, approximately 82% of global off-grid solar volume, but only 20% of MW shipped, was for lighting products under 10 W.
 - The top-selling off-grid solar product is the single light with mobile charging. It accounted for almost half of off-grid product sales worldwide.
- In 2019, solar home systems (SHSs) accounted for approximately 18% of global off-grid solar volume and 80% of MW shipped.



1 Global Solar Deployment

2 CSP Deployment

3 U.S. PV Deployment

4 PV System Pricing

5 Global Manufacturing

6 Component Pricing

Market Activity

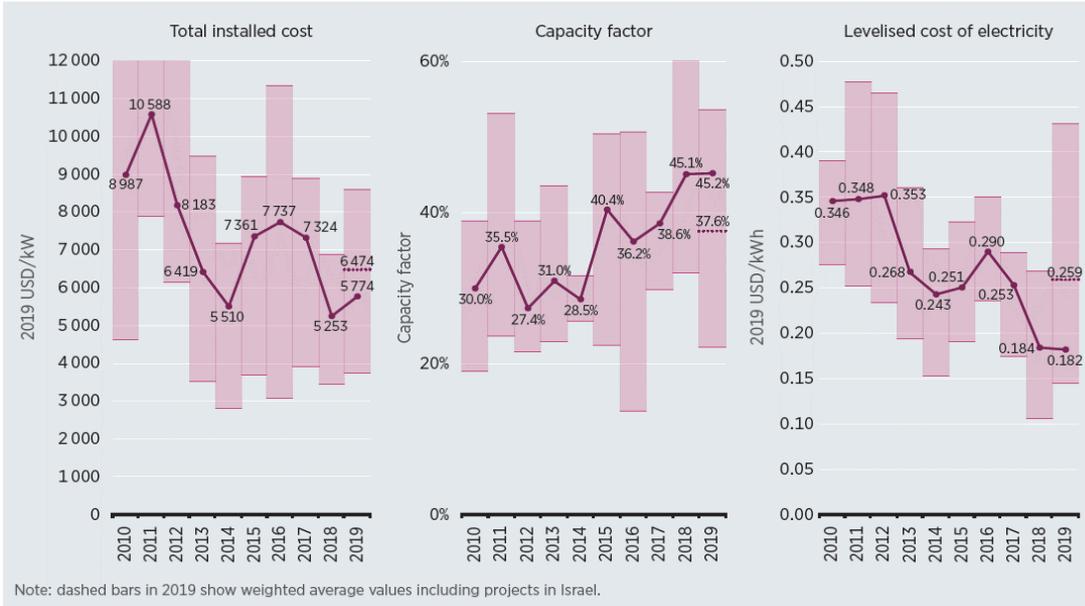
- **Tonopah Solar, the owner of the first large-scale (110 MW) solar tower with molten-salt storage, declared bankruptcy in July 2020, having not operated since April 2019.**
- **In June, the first Fresnel plant with molten salt storage began commercial operation in China.**
- **IRENA reports that the weighted-average LCOE of CSP plants fell 47% from 2010 to 2019, to \$0.18/kWh (excluding two projects in Israel that were significantly delayed)—and will drop to \$0.075/kWh in 2021—a 59% reduction.**

CSP Updates

- Tonopah Solar, the owner of the first large-scale (110 MW) solar tower with molten-salt storage, declared bankruptcy in July 2020, having not operated since April 2019.
 - Its energy storage salt tanks suffered from a string of leaks soon after it began operation, and its PPA was cancelled last October.
 - The project still owes \$425 million on its DOE loan, though has made a deal to pay back \$200 million (subject to court approval).
- In July, Australia and Cyprus made headway for their first (50 MW) solar thermal plants.
 - Portugal was also expected to award a CSP project with its first solar-plus-storage auction; however, it appears as if no CSP projects had winning bids. The auction was technology agnostic, but CSP was expected to benefit from CSP groups in neighboring Spain, high direct normal radiance, and recent cost reductions for larger projects.
- In June, the first Fresnel plant with molten salt storage began commercial operation in China. The plant was connected to the grid in December 2019 and has since advanced through the commissioning phase.
- In June, Abengoa announced it would install its first retrofit CSP storage pilot in Spain.
 - 1.2 GW of Spain's 2.3 GW of CSP operates without storage, and the large increase in wind and solar in Spain has pushed the need for more storage.

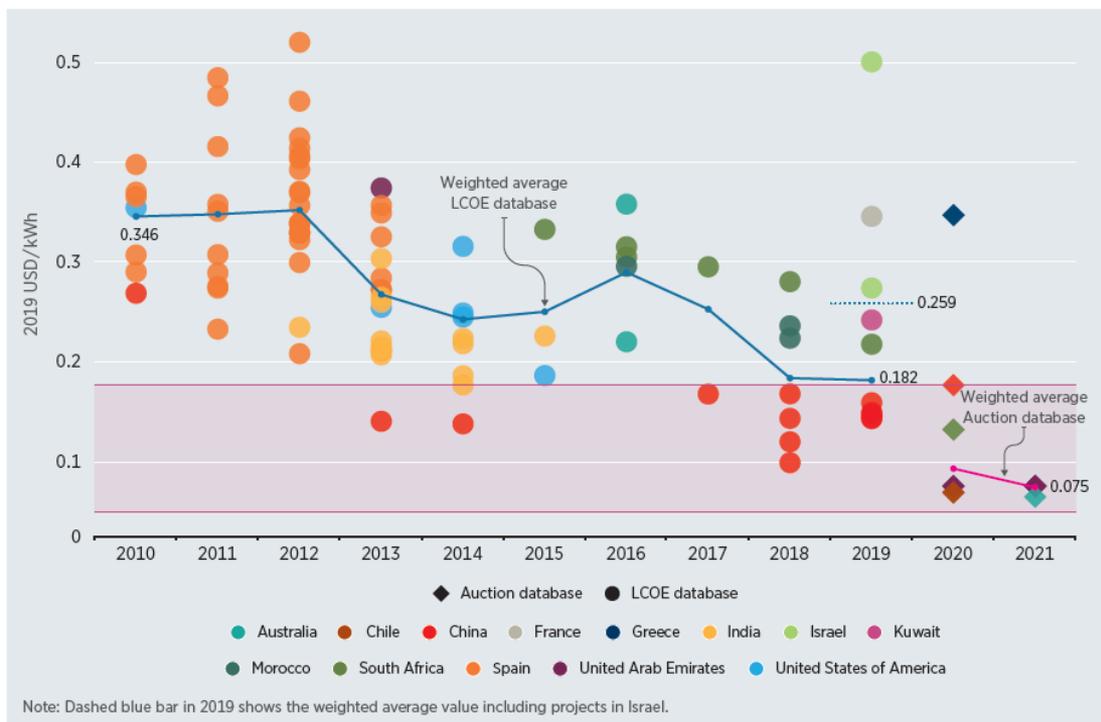
CSP Global Averages

- IRENA reports that the weighted-average LCOE of CSP plants fell 47% from 2010 to 2019, to \$0.18/kWh.
- In 2019, the global weighted-average total installed cost was \$5,774/kW, with prices ranging from \$3,741/kW to \$8,595/kW, depending on storage and other factors.
- Average capacity factor of CSP plants increased from 30% in 2010 to 45% in 2019 as a result of technology improvements, deployment occurring in better solar resource areas, and increased use of and levels of storage.



Source: IRENA Renewable Cost Database.

CSP LCOE and Auction Data



Source: IRENA Renewable Cost Database and IRENA Auction and PPA Database.

- IRENA reports that based on awarded bids for projects to be built in 2020–2021, the weighted-average price of electricity for CSP is expected to drop from \$0.182/kWh in 2019 to \$0.075/kWh in 2021—a 59% reduction.
- Chinese CSP plants have LCOEs on the lower end of the range; however, the lowest-priced bids for projects to be placed in service in 2020–2021 are reported in Chile, Australia, and the United Arab Emirates.



1 Global Solar Deployment

2 CSP Deployment

3 **U.S. PV Deployment**

4 PV System Pricing

5 Global Manufacturing

6 Component Pricing

Market Activity

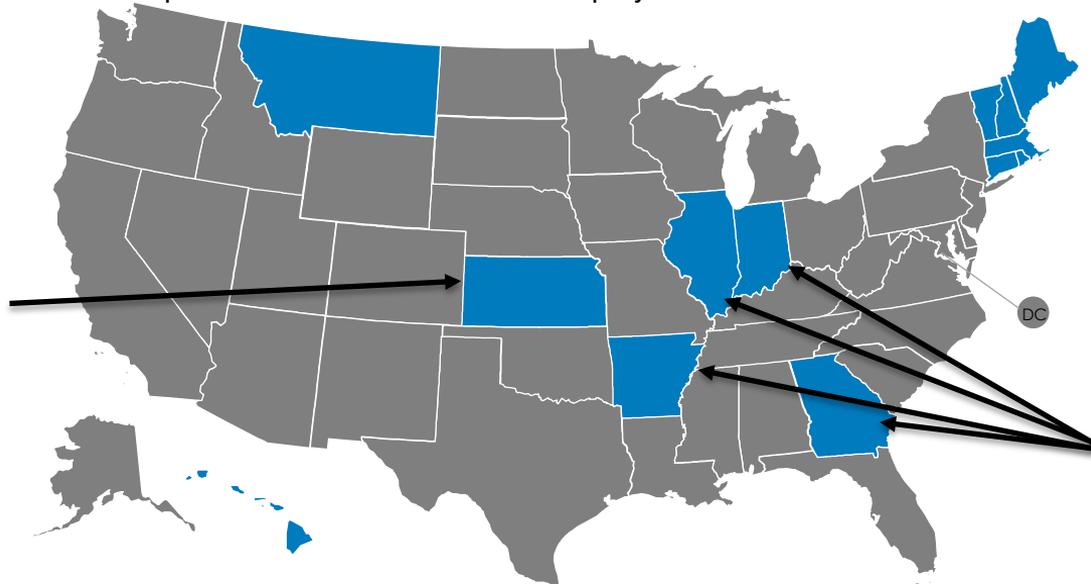
- **Ten states generated more than 5% of their electricity from solar, with California leading the way at 21.7%.**
- **Despite possible effects of COVID-19, the United States installed 7.2 GW_{DC} of PV in H1 2020, its largest H1 total ever—up 48% y/y.**
- **The United States installed approximately 208 MWh (98 MW) of energy storage onto the electric grid in Q1 2020—down 34% y/y.**

States Updates

Source: Meister Consultants Group, *50 States of Solar: Net Metering Quarterly Update (Q2 2020)*.

In August, the Montana Supreme Court ruled that state regulators acted illegally when they reduced the prices and contract terms for PV projects.

In April, the Kansas Supreme Court ruled that mandatory residential DG demand charges approved by the utility commission were a form of price discrimination.

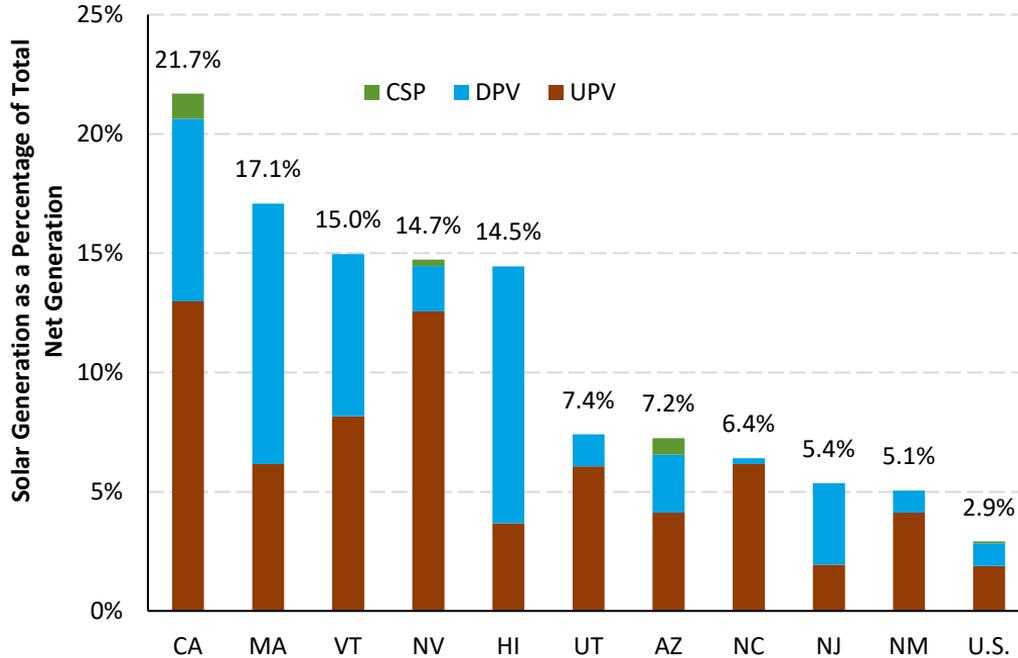


In April 2020, the New England Ratepayers Association filed a petition with FERC saying that net metering should be treated as wholesale energy sales and regulated at the federal level under PURPA. The petition was dismissed in July 2020.

In April 2020, Hawaii greatly expanded its community solar offering from 8 MW to 235 MW, providing more access to the LMI sector.

States, such as Arkansas, Indiana, Georgia, and Illinois, are establishing dates or DG capacity levels at which they will transition to net-metering successor programs.

Solar Generation as a Percentage of Total Generation, H2 2019–H1 2020



Note: EIA monthly data for 2019 and 2020 are not final. Additionally, smaller utilities report information to EIA on a yearly basis, and therefore a certain amount of solar data has not yet been reported. “Net Generation” includes DPV generation. Net generation does not take into account imports and exports to and from each state, and therefore the percentage of solar consumed in each state may vary from its percentage of net generation.

Source: U.S. Energy Information Administration (EIA), “Electricity Data Browser.” Accessed August 25, 2020.

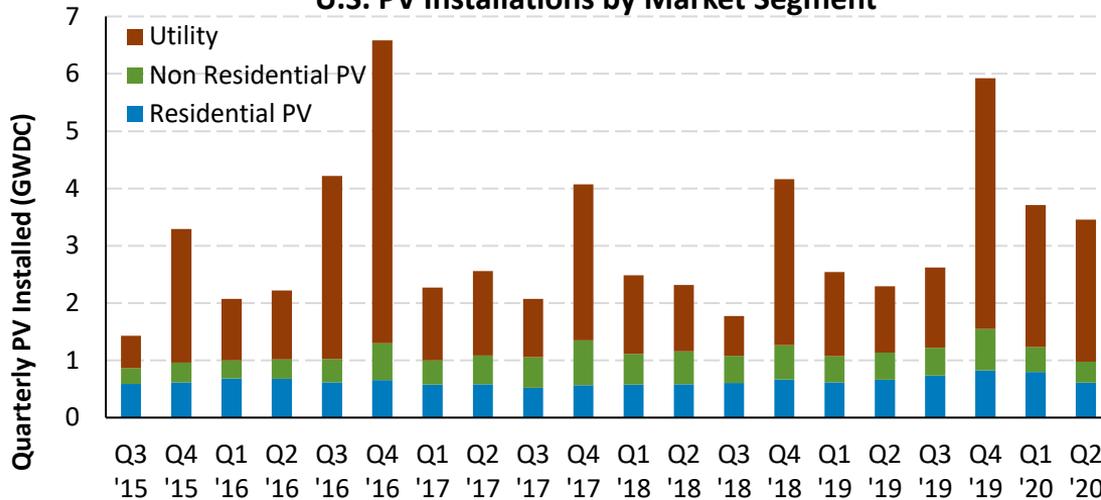
- During H2 2019–H1 2020, 10 states generated more than 5% of their electricity from solar, with California leading the way at 21.7%.
 - Five states generated more than 14% of their electricity using solar.
 - Nationally, 2.9% of electricity was generated from solar.
- The role of utility versus distributed solar varies by state, with northeastern states and Hawaii relying more on DPV.

U.S. Installation Breakdown Quarterly

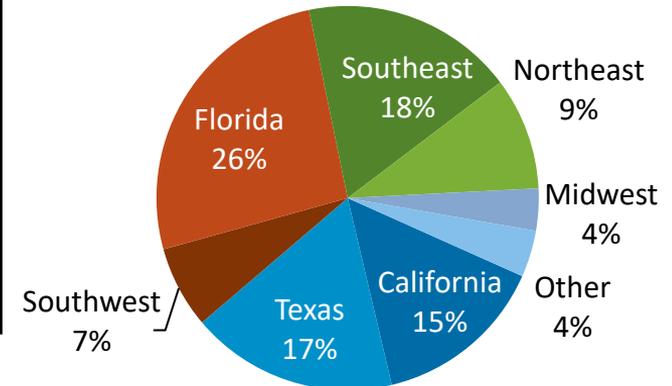
- Despite the impact of COVID-19 on the overall economy, the United States installed 7.2 GWDC of PV in H1 2020, its largest H1 total ever—up 48% y/y.
 - While the utility sector was up 89% y/y, the nonresidential sector was down 14%.

- Approximately 58% of U.S. PV capacity installed in H1 2020 occurred in California, Texas, and Florida.
- With the continued diversification of PV markets across the United States, the market share of California during H1 2020 was at its lowest level on record.

U.S. PV Installations by Market Segment



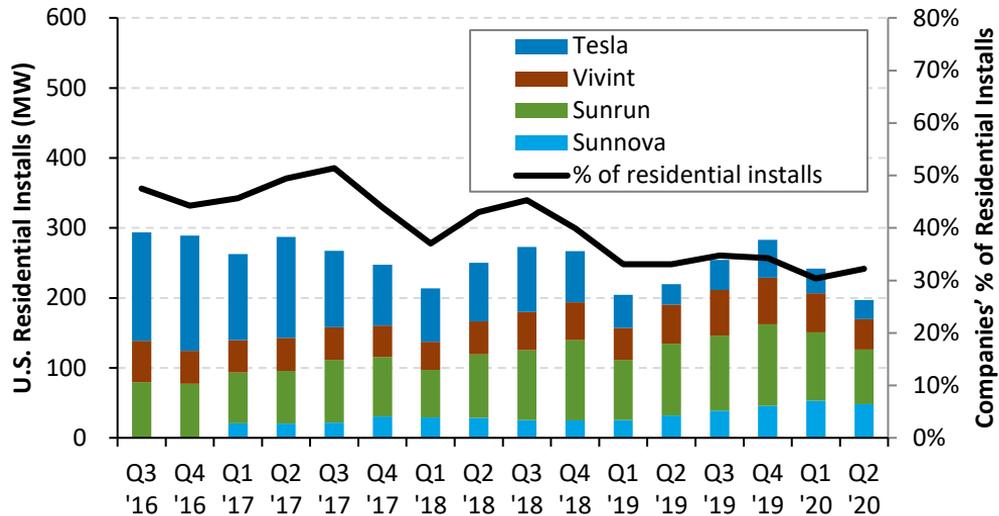
H1 2020 U.S. PV Installations by Region (7.2 GWDC)



Tesla, Vivint Solar, Sunrun, and Sunnova

Residential Market Share

- H1 2020 residential PV installations from four of the leading national installers were relatively flat y/y, totaling approximately 439 MW.
 - Growth in the first quarter was counterbalanced by reduced installs in Q2, likely due to the pandemic.

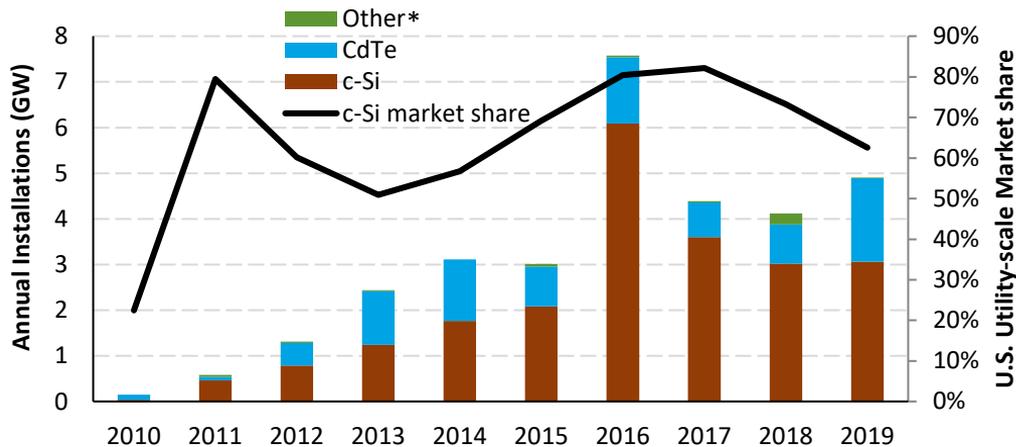


Source: Corporate filing, SEIA/Wood Mackenzie [Solar Market Insight Q3 2020](#).

- In Q2 2020, Tesla had its lowest PV installation level since 2012, 27 MW. However:
 - Tesla also reported a tripling from Q1 2020 to Q2 2020 of its solar roofs (though CA NEM only reports 42 Tesla solar roofs from January to April 2020).
 - In late June Tesla announced a new sales strategy of standard-sized systems, which it was selling for ~\$2/W.
 - In Q2 2020 Tesla reported 419 MWh of energy storage sales—its third highest quarter on record.
- While direct sales and loans represent a sizable part of national integrators' sales, the bulk of their installations are through leases and PPAs.
 - Leases and PPAs represented 78% to 87% of national integrators' sales in Q2 2020 (excluding Tesla, which did not report its percentage).

U.S. Utility-Scale Characteristics

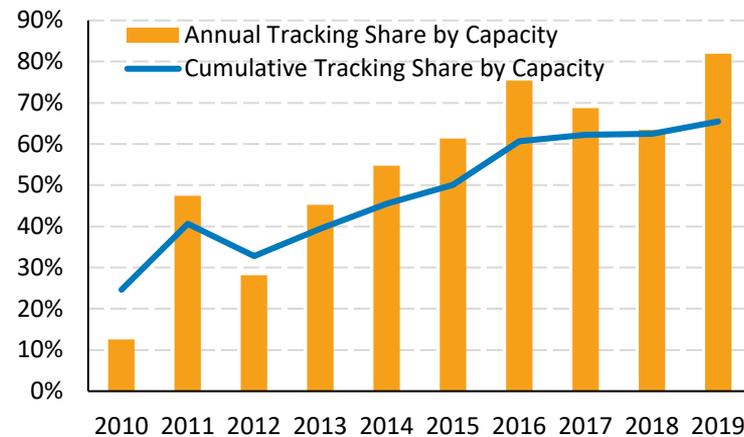
- While thin-film PV represented less than 5% of global PV deployed from 2010 through 2019, it accounted for 30% of U.S. utility-scale PV deployments during this period.
 - In 2019 CdTe PV accounted for 37% of U.S. utility-scale PV.
 - For First Solar, the leading supplier of CdTe modules, the U.S. market has been critical, accounting for 87% of its revenue from 2015 through 2019.



* "Other" could represent data entry errors.

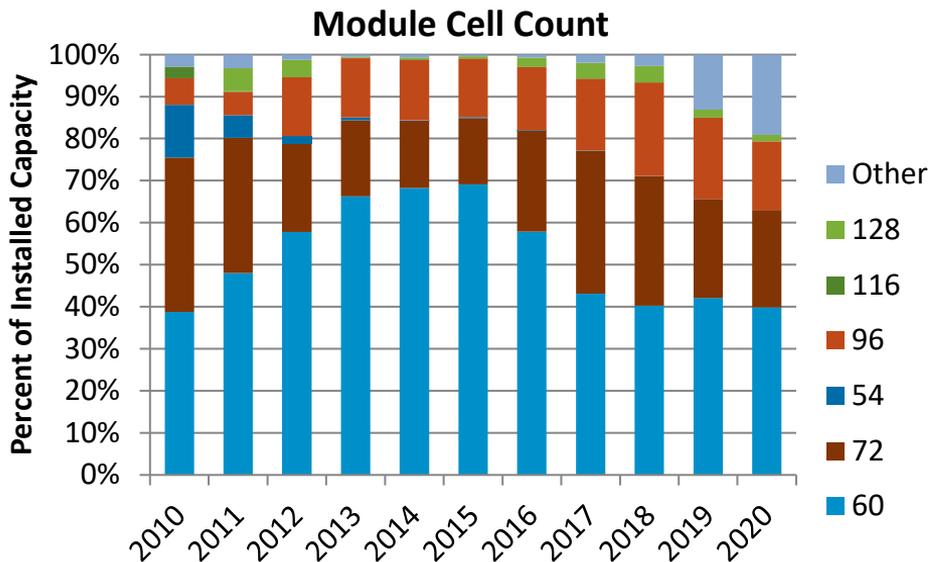
Source: U.S. EIA, Form EIA-860 2019ER. Data represents PV systems greater than 5 MW.

- The use of single-axis tracking in the U.S. utility PV market has grown steadily over the past decade.
 - At the end of 2019, 65% of all U.S. utility-scale PV systems used single-axis tracking.
 - 82% of U.S. utility-scale PV systems installed in 2019 used single-axis tracking.
- While IPPs own a majority of U.S. utility-scale PV systems, regulated utilities owned 15% of systems installed in each of the past 3 years.
 - Most of the utility-owned PV systems are in the Southeast.

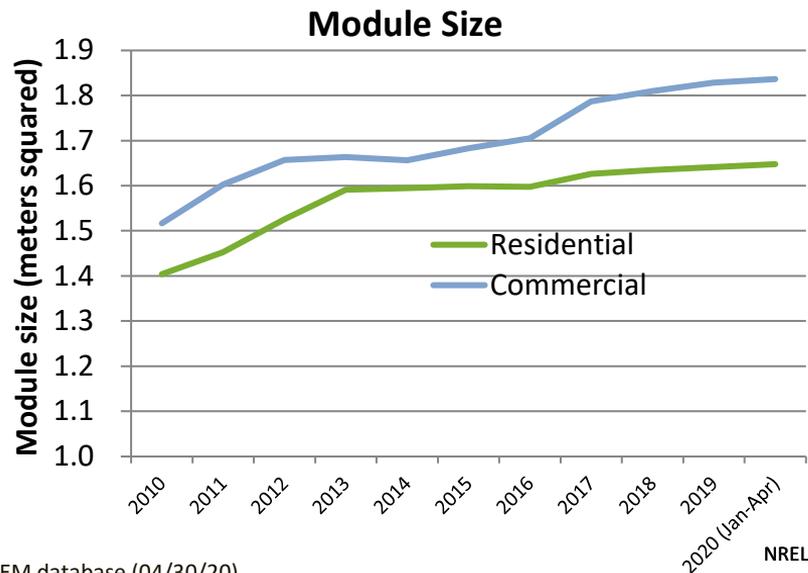


Module Characteristics Within CA NEM Data Set

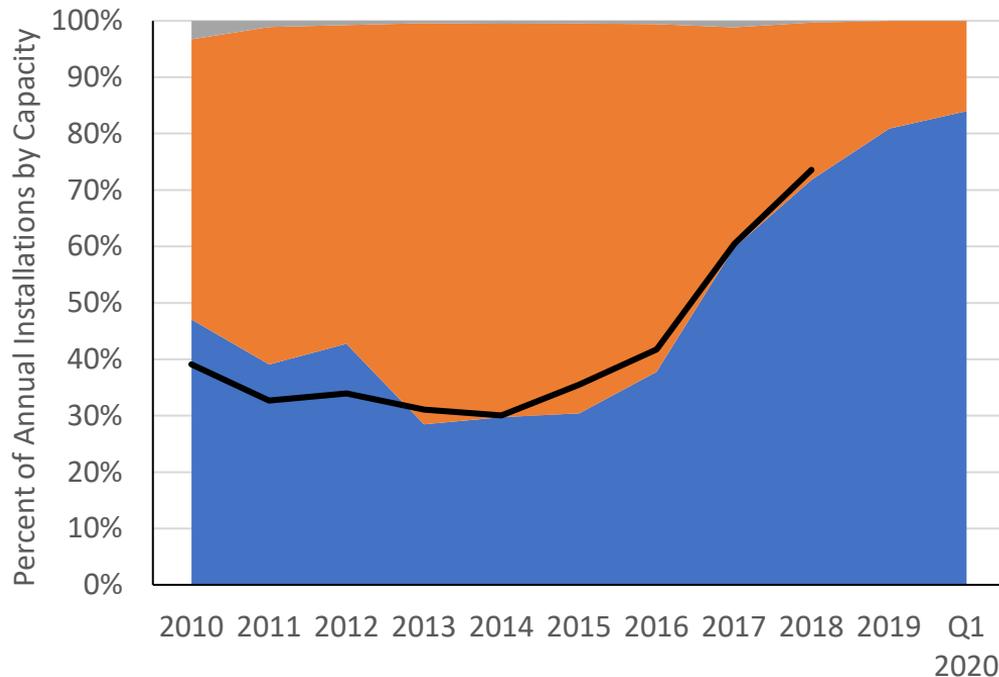
- 60- and 72-cell modules have historically been 75% to 85% of the installed capacity within California's NEM data set but have recently been losing market share to modules with other cell counts.
- The average size of modules in the residential and commercial spaces grew 17% and 21%, respectively, from 2010 through 2019.



- Although bifacial panels have recently captured a significant market share in the United States, in the first four months of 2020, they only represented 0.5% of the installed capacity within the CA NEM data set—1.7% for commercial systems.
 - That level for commercial systems still represents a significant jump from 0.1% of installed capacity in 2018 and 0.4% in 2019.
- Tesla is ramping the scale-out of its sunroof tiles, growing from 8 systems in 2017 to 42 systems in the first 4 months of 2020—still less than 2 MW of cumulative installed capacity after announcing plans for a Gigafactory several years ago.



Module Technology Within CA NEM Data Set



■ Mono-c-Si (CA NEM)

■ Multi-c-Si (CA NEM)

■ Thin Film (CA NEM)

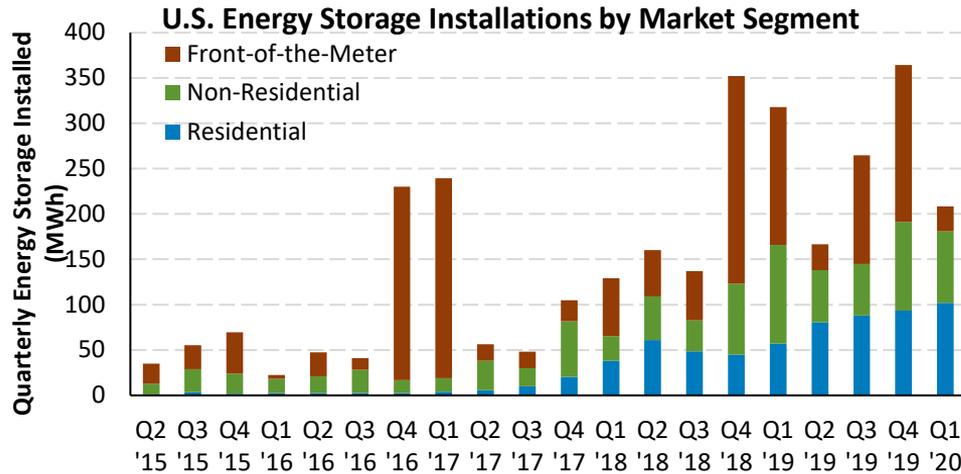
— Mono-c-Si (Tracking the Sun)

- Following global trends, California distributed PV systems have transitioned from using multicrystalline to monocrystalline modules.
 - Monocrystalline represented 30% of capacity installed in 2015 in the CA NEM data set but represented 84% of capacity installed in Q1 2020.
 - California trends have historically been fairly close in relation to national distributed PV trends captured in *Tracking the Sun*.

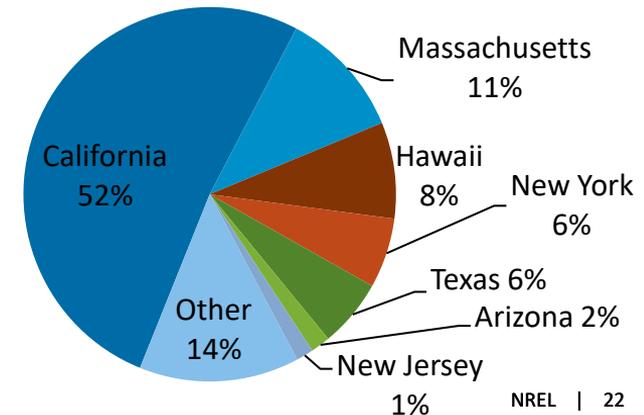
U.S. Energy Storage Installations by Market Segment

- The United States installed approximately 208 MWh (98 MW) of energy storage onto the electric grid in Q1 2020, down 34% y/y, mostly due to lower levels of front-of-the-meter installations.
- Behind-the-meter installs were up 9% y/y, as residential posted another record-breaking quarter.

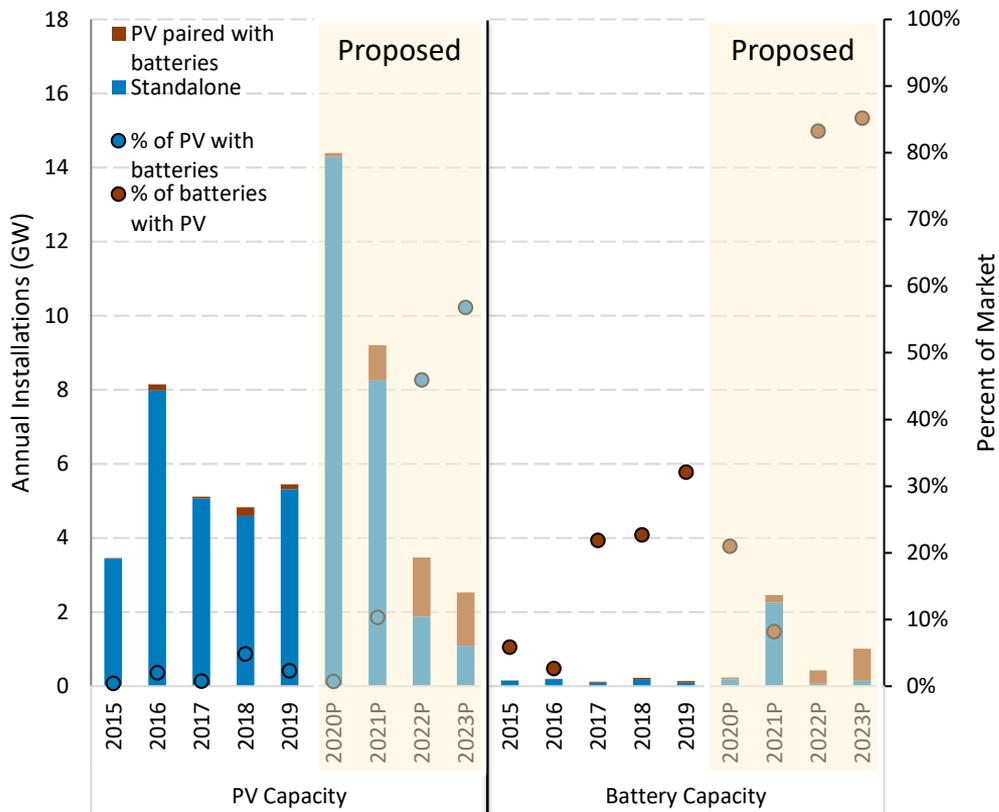
- Wood Mackenzie reports that the pandemic's effect on the U.S. storage market mostly occurred after Q1 2020, with more difficulty in customer acquisitions, installations, and interconnections due to shelter-in-place practices.
- Massachusetts recently changed its SMART program, requiring all PV systems greater than 500 kW to have storage attached.
- Southern California Edison announced 770 MW, and Pacific Gas & Electric announced 423 MW of storage procurement to be installed in 2021. In 2019 U.S. storage installs were 523 MW.



Q1 2020 U.S. Energy Storage Installations by Region (208 MWh)

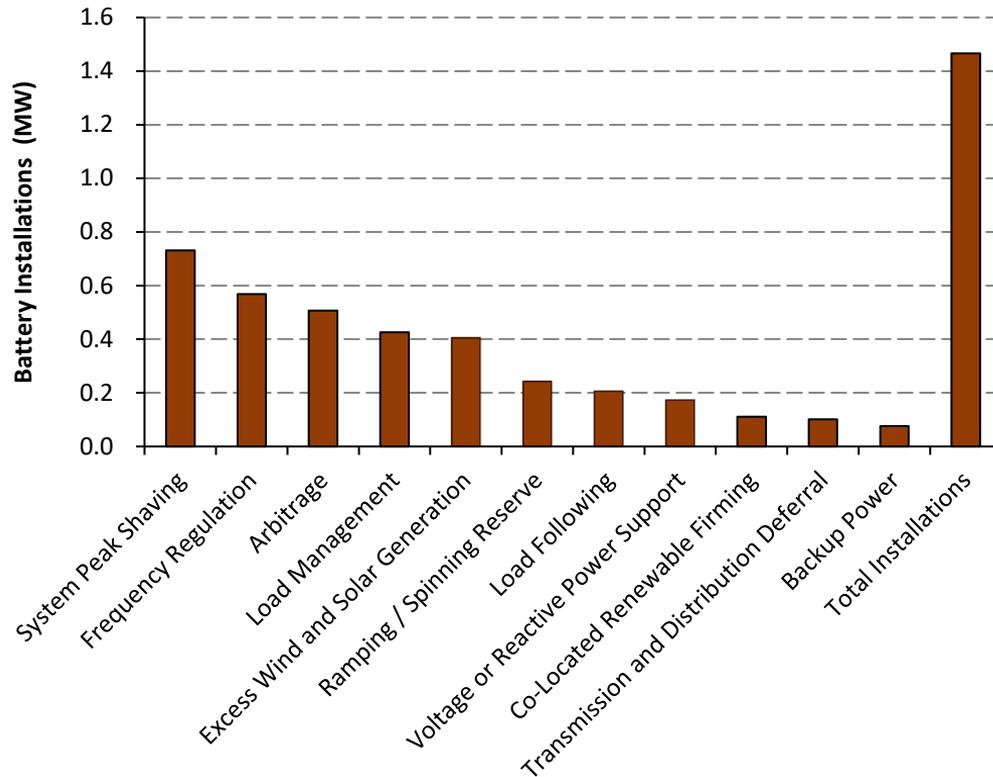


U.S. Utility-Scale PV and Batteries



- From 2015 through 2019 approximately 581 MW of U.S. utility-scale PV systems were built, paired with 138 MW of storage (387 MWh), representing approximately 2% of U.S. utility-scale PV system capacity and 16% of utility-scale battery system capacity (MW) installed during that time.
 - 46% of utility-scale battery capacity installed between 2015 and 2019 was paired with PV, in MWh capacity.
- EIA reports that another 4.1 GW of utility-scale PV are proposed to be built, paired with 1.5 GW of battery storage, from 2020 through 2023.
 - These systems represent 14% of all PV systems proposed to be built during that time.

U.S. Utility-Scale Batteries (with and without PV), 2015–2019



- In addition to the 387 MWh of U.S. battery storage paired with PV from 2015 through 2019, another 1.1 GWh of storage was added to the U.S. grid as independent systems.
- In total, these systems reported a variety of applications—often serving more than one function.
 - The five most popular applications reported were:
 - Peak shaving (50%)
 - Frequency regulation (39%)
 - Arbitrage (35%)
 - Load management (29%)
 - Excess wind and solar generation (28%).



1 Global Solar Deployment

2 CSP Deployment

3 U.S. PV Deployment

4 **PV System Pricing**

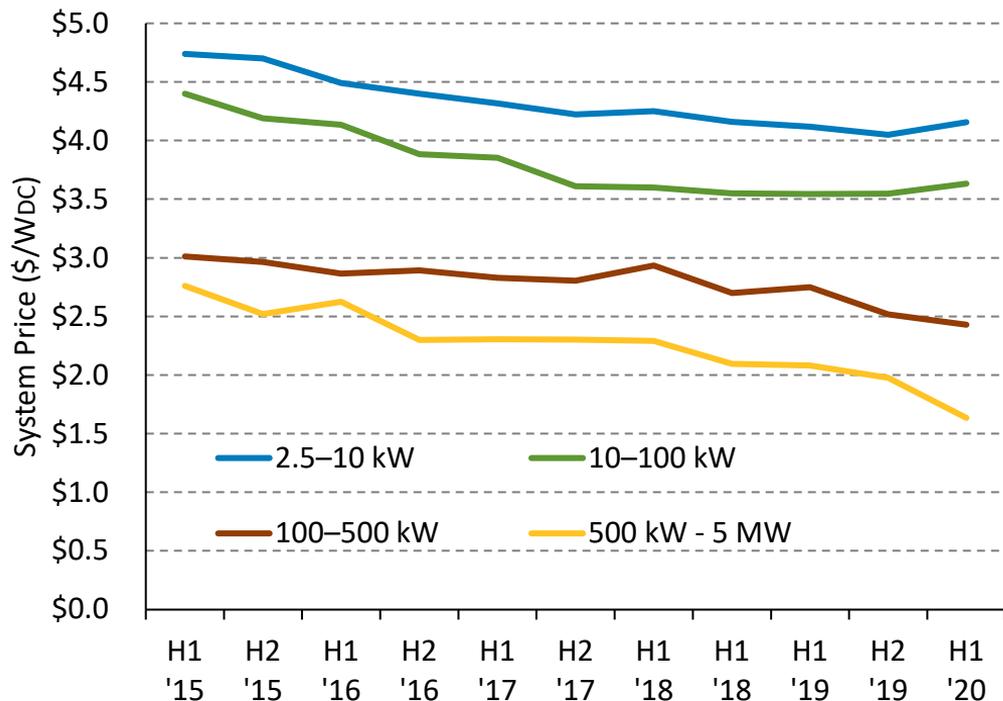
5 Global Manufacturing

6 Component Pricing

Market Activity

- **The reduction of the residential ITC from 30% to 26% in 2020 does not appear to have reduced reported prices for smaller systems, on average.**
- **In Q2 2020, Sunrun and Vivint Solar’s system costs (including installation, sales, and G&A) were \$3.5/W–\$4.0/W, and net values were \$4.0/W–\$5.0/W.**
- **In July 2020, Sunrun agreed to purchase Vivint for \$3.2 billion (in an all stock swap transaction).**

System Pricing From Select States



- The reduction of the residential ITC from 30% to 26% in 2020 does not appear to have reduced reported prices for smaller systems, on average.
- From H1 2019 to H1 2020, the median reported PV system price in Arizona, California, Connecticut, Massachusetts, and New York:
 - Increased 1% to \$4.16/W for systems from 2.5 kW to 10 kW
 - Increased 2% to \$3.63/W for systems from 10 kW to 100 kW
 - Fell 12% to \$2.43/W for systems from 100 kW to 500 kW
 - Fell 21% to \$1.53/W for systems from 500 kW to 5 MW.

H1 2020 MW: AZ (16), CA (270), CT (2.4), MA (43), NY (160)

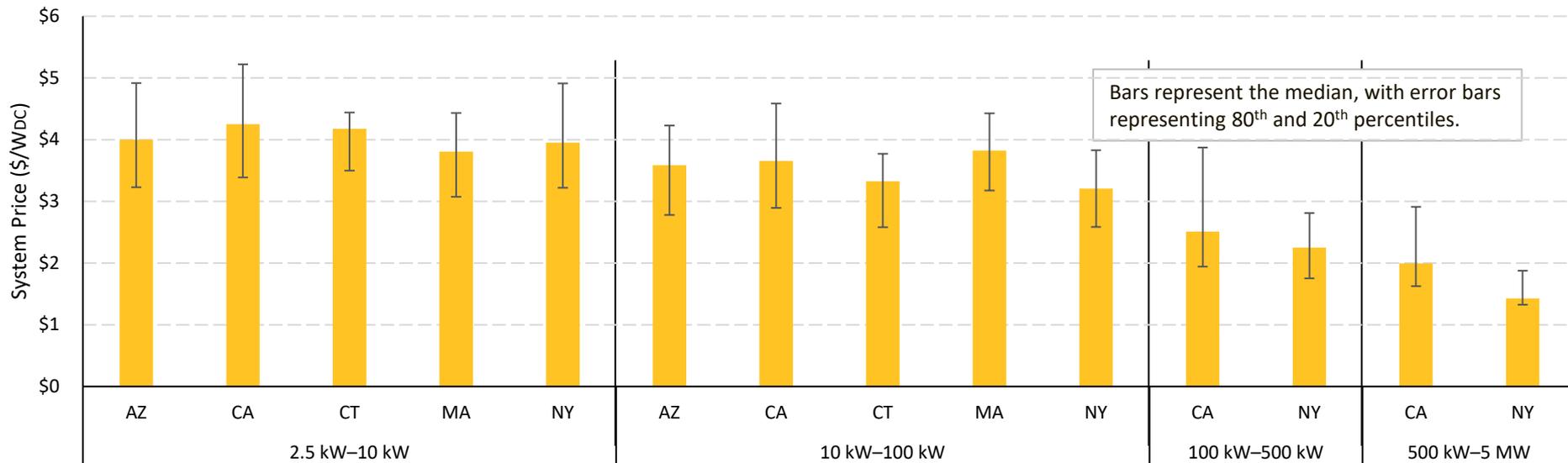
Note: System prices above \$10/W and below \$1/W were removed from the data set.

Sources: AZ (08/20/20), CA NEM database (04/30/20); CT (08/01/20), MA SREC and SMART programs (08/17/20); NYSERDA (08/28/20).

System Pricing From Select States, H1 2020

- In addition to price differences based on system size, there is also 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 20th and 80th percentile preliminary prices in California for a small system were \$3.39/W and \$5.22/W, respectively.

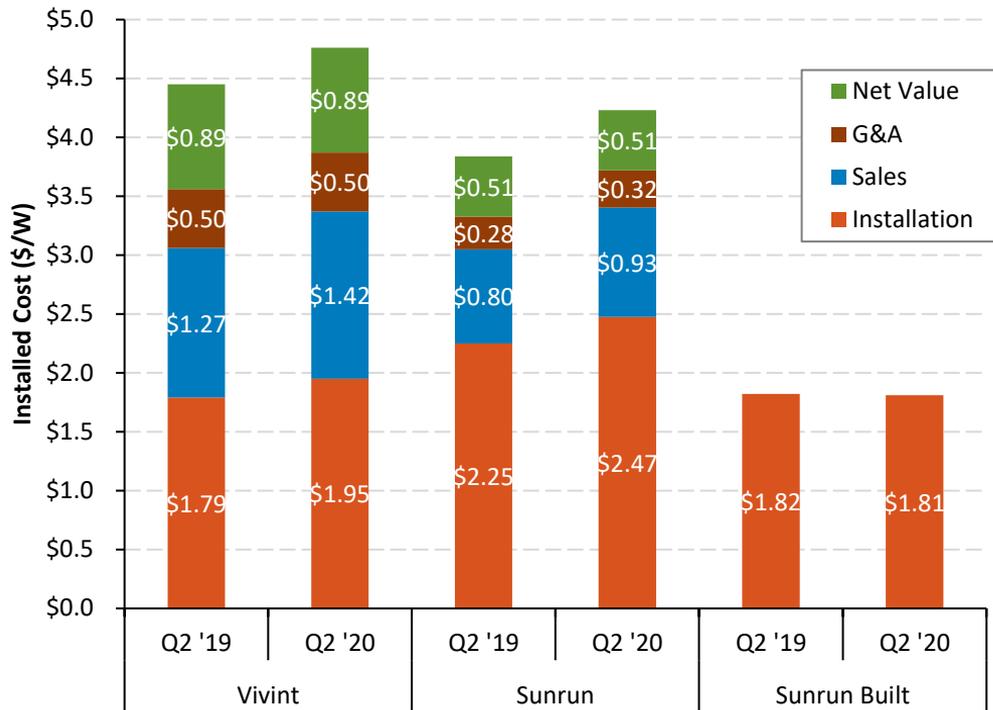


H1 2020 MW: AZ (16), CA (270), CT (2.4), MA (43), NY (160)

Note: System prices above \$10/W and below \$1/W were removed from the data set.

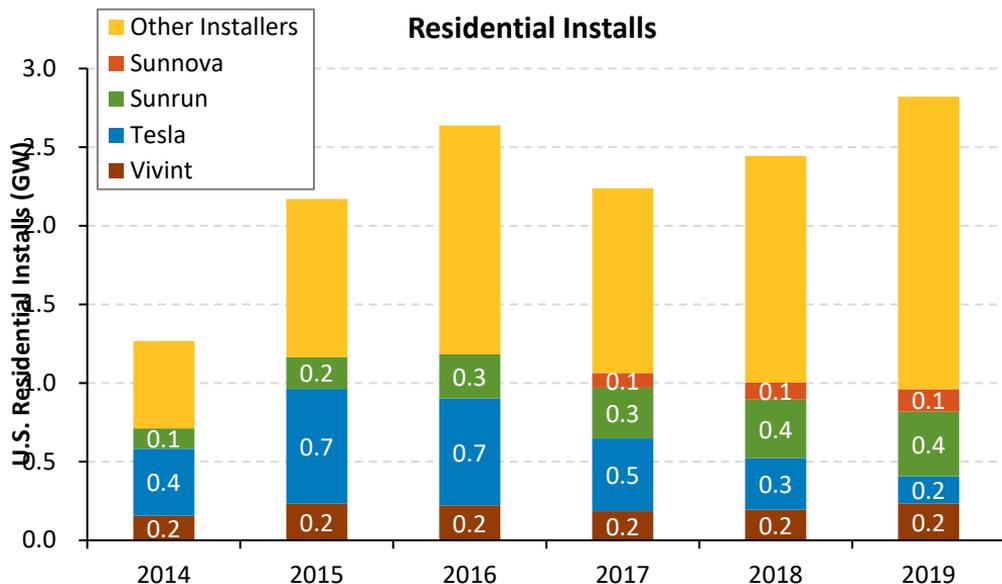
Sources: AZ (08/20/20), CA NEM database (04/30/20); CT (08/01/20), MA SREC and SMART programs (08/17/20); NYSERDA (08/28/20).

Sunrun and Vivint Solar Cost and Value, Q2 2020



- In Q2 2020, Sunrun and Vivint Solar’s system costs (including installation, sales, and G&A) were \$3.5/W–\$4.0/W, and net values were \$4.0/W–\$5.0/W.
- Vivint Solar and Sunrun’s costs increased y/y due to increasing installation and customer acquisition costs, compounded by lower installations caused by the pandemic.

Sunrun–Vivint Deal (History)



- In 2011, Vivint Solar was established in Salt Lake City as a pioneer of the door-to-door sales approach. The company was founded by Mormons, who used ex-missionaries, already trained at door-to-door work, to sell solar.
- In 2014, when SolarCity, Vivint Solar, and Sunrun represented 56% of U.S. residential PV installations, they all issued IPOs.
- In 2015, SolarCity peaked in deployment with 731 MW—or one-third of the market. Additionally, SunEdison tried to get into the residential PV sector by buying Vivint Solar for \$2.2 billion. That deal was one of the last straws for SunEdison, which went bankrupt—the deal never went through.
- In 2016, Tesla bought SolarCity for \$2.6 billion. It was viewed as a bailout for a company that was heading into financial trouble, and Tesla has been downsizing its solar business since.
 - SolarCity’s massive growth cost a lot.
- In the last 3–4 years, Sunrun has been growing, Vivint Solar has been recovering from a failed merger, and Tesla has shrunk its business.
- In 2019, Sunrun and Vivint represented approximately 20% of the residential market—there is still a very long-tailed distribution of residential PV installers.

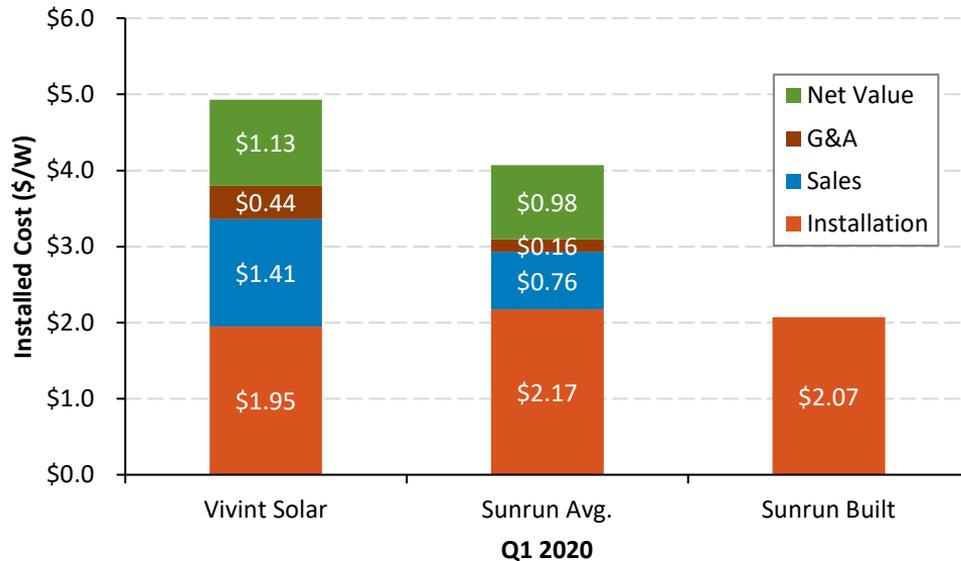
Sunrun–Vivint Deal Overview

- In July 2020, Sunrun agreed to purchase Vivint for \$3.2 billion (in an all stock swap transaction).
 - The deal is expected to close in Q4 2020. The head of Vivint will chair the integration committee, and Vivint sales staff will be a large part of the new company.
 - Increases value of grid-services business model by having larger portfolio of assets to control for grid.
 - Sunrun currently has a contract in ISO-NE for 20 MW of grid services but might not have gotten to that number of needed batteries without Vivint’s fleet.
 - How valuable are grid services now? Industry might need more maturity before there is large growth in that area, and it is unclear who will control that (e.g., utility, third party, customer).
 - Bigger is better: because of the ITC, COVID, and economic downturn, small companies are suffering more than large companies. With balance sheet and reach, Sunrun and Vivint may be better able to manage disruptions.
 - Vivint was going to have a challenge competing without Sunrun. It had been struggling economically since SunEdison, was smaller in size and slower to adopt newer services (e.g., storage).
- Rationale for deal:**
- The companies report there will be \$90 million in operational cost synergies (or 4% of cost stack).
 - Branch consolidation, crew consolidation, shared corporate function (HR, legal, policy)
 - More leverage in procuring equipment translating into lower hardware costs
 - Better terms of financing. A larger balance sheet will allow them to raise debt more easily, reduce friction costs, and attract larger investors who may have higher investment thresholds.

Source: GTM: “Sunrun Buying Vivint: Unpacking the Biggest Distributed Solar Deal in History.”

Sunrun–Vivint Deal Customer Acquisition

- Perhaps the largest reason for a merger would be a reduction in customer acquisition costs.
 - Customer acquisition represents a significantly higher percentage of costs than other overhead costs, and a much greater opportunity for reduction with merger than hardware costs.



- Sunrun and Vivint have differing customer acquisition approaches and would bring a large door-to-door ability to their sales team.
 - While the companies' territories overlap a lot, there are likely different customers who respond to door-to-door versus other sales approaches.
 - Due in large part to the pandemic, door-to-door sales is suffering, with many states (NJ, IL, PA, NY) banning the practices. Companies are switching to digital/online sales approaches. Sunrun is possibly betting on an outdated sales approach.
- Customer acquisition has increased for larger installers.
 - Local installers may pay \$0.20/W in customer acquisition, whereas national integrators may pay \$1/W.
 - Vivint and Sunrun have been in a bidding war for leads, driving up cost. By removing their largest competitor, there will be much less competition for leads.**
 - Does competition resurface with mid-tier companies?
 - Also a possibility to retrofit Vivint Solar's customers with storage; however, retrofits represent a very small percentage of the market as their costs are much greater.



1 Global Solar Deployment

2 CSP Deployment

3 U.S. PV Deployment

4 PV System Pricing

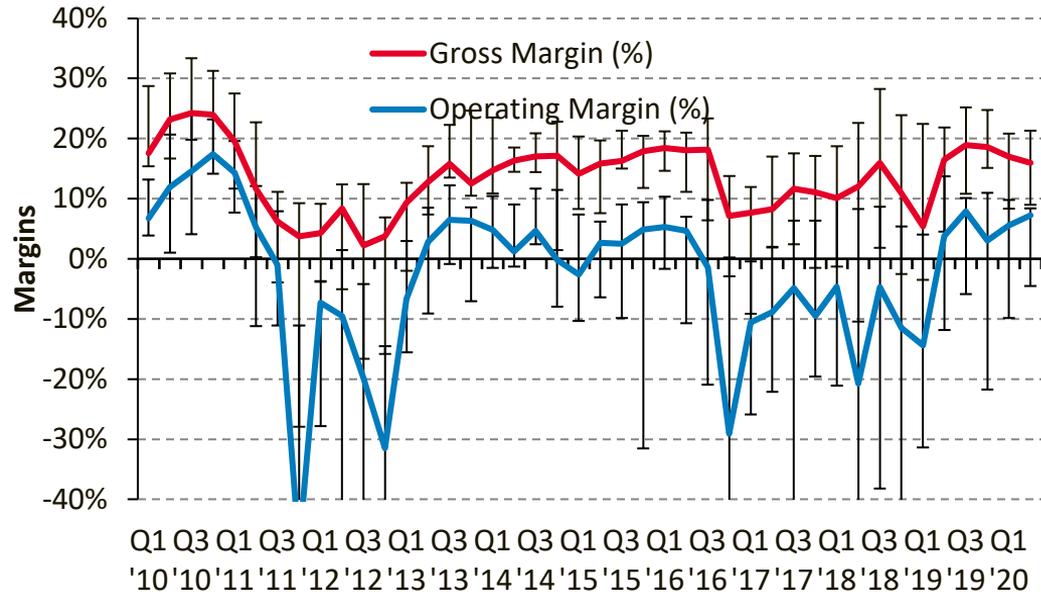
5 **Global Manufacturing**

6 Component Pricing

Market Activity

- **PV manufacturers' gross margins declined in Q2 2020, on average; however, operating margins improved and are still at relatively high levels historically.**
- **In 2018, 56% of Jinko Solar's module shipments were multicrystalline. In 2020, it expects to almost double its module shipments, which will be virtually all high-efficiency monocrystalline.**
- **Despite tariffs, PV modules and cells are being imported into the United States at historically high levels, with 14.2 GW of PV modules and 1.3 GW of PV cells in H1 2020.**
 - **First Solar's 1.9-GW thin-film plant was also operating at a relatively high utilization rate.**
- **Since late 2019, a growing amount of PV imports into the United States are from China, despite continued tariffs.**

PV Manufacturers' Margins



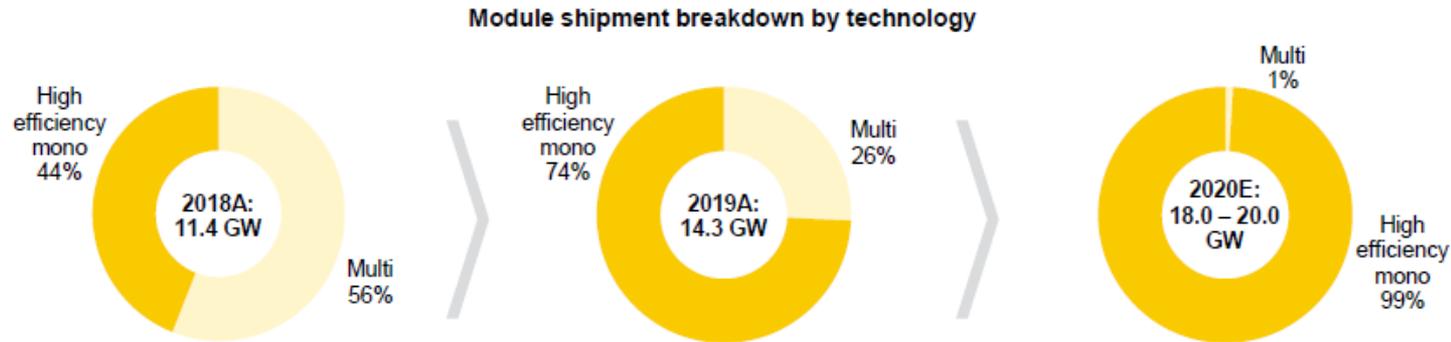
- The median gross margin of the publicly traded PV companies represented to the left declined in Q2 2020; however, operating margins improved and are still at relatively high levels historically.
- There continues to be significant variation by individual companies as individual factors come into play.

Line represents the median, with error bars representing 80th and 20th percentiles for the following companies in Q2 2020: Canadian Solar, First Solar, LONGi, Motech Industries, Tongwei, SunPower, Trina Solar, and United Renewable Energy. Margin data from Hanwha Q Cells, Jinko Solar, JA Solar, Renesola, Risen Solar, Shanghai Aerospace, and Yingli are also included from Q1 2010 to Q1 2020 where available.

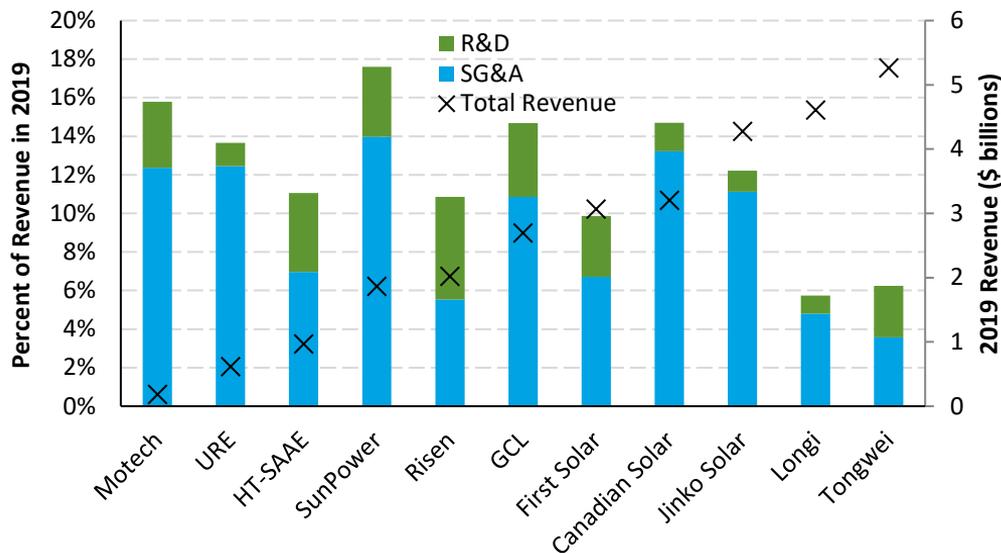
Case Study: Jinko Solar Switch in Technologies

- In 2018, 56% of Jinko Solar's 11.4 GW in module shipments were multicrystalline.
- In 2020, Jinko Solar expects to almost double its module shipments to roughly 20 GW and shift production to 99% high-efficiency monocrystalline.

- 40% of the 2020 shipments are expected to be next-generation products:
 - A bifacial module with module efficiencies up to 19.5%
 - Tiling ribbon module with module efficiencies up to 20.8%
 - N-type module with maximum module efficiencies of 21.4%.

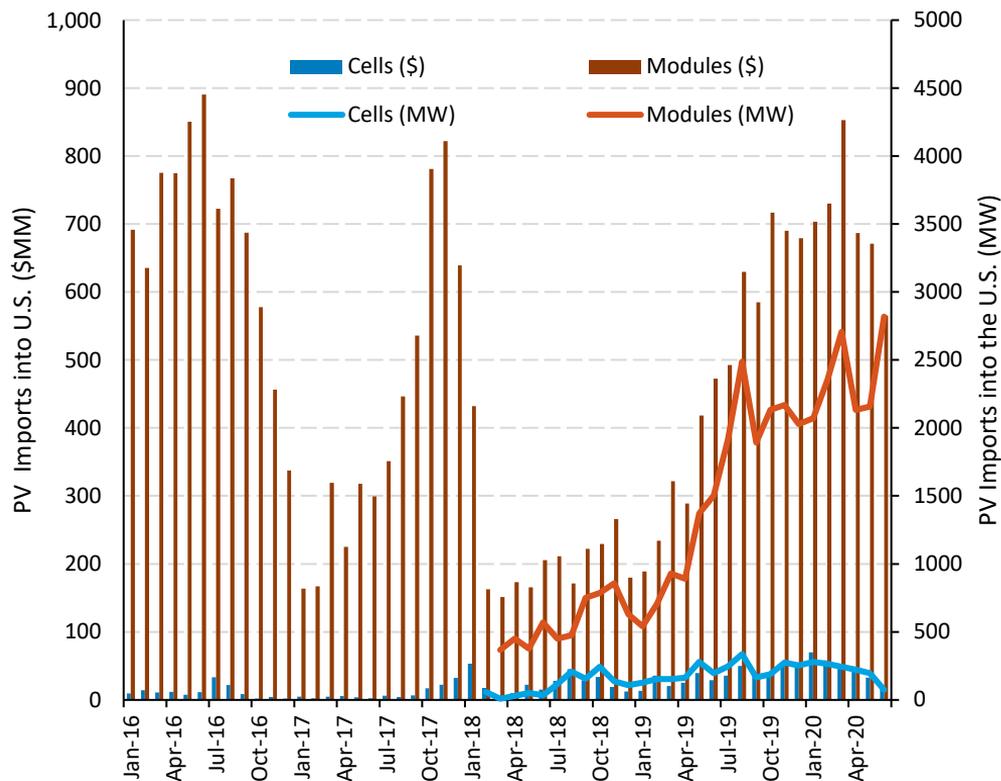


Operating Expenses by Company Size



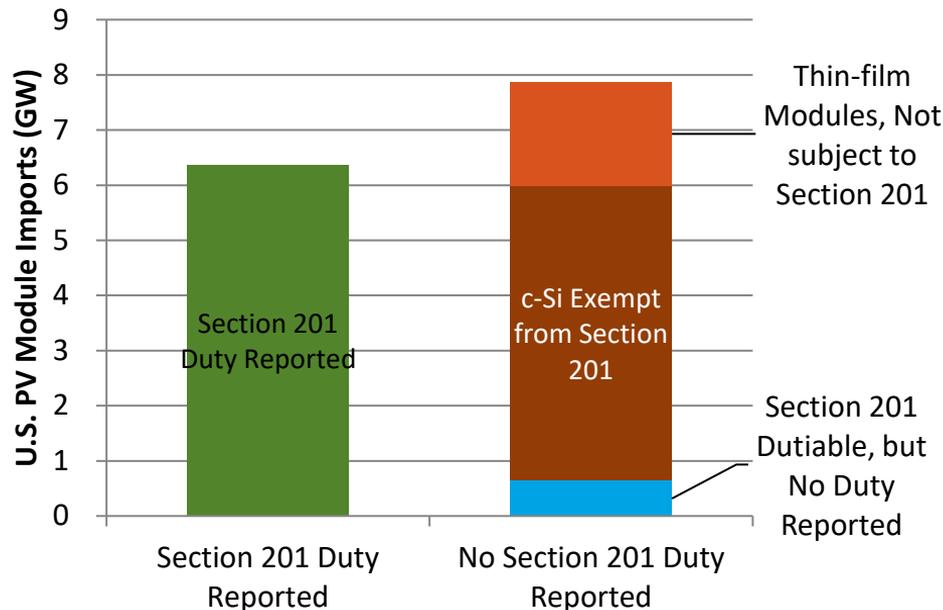
- Larger companies have a competitive advantage due to scale.
- Within the solar sector, the operating expenses of larger companies are a smaller fraction of total revenue than those of smaller companies, on average.
 - Due to efficiencies of scale, larger companies can spread these costs over more sales.
 - Individual company expense ratios vary, based on performance, strategy (e.g., spending more on R&D), and subsector (e.g., polysilicon production versus module production).

Module and Cell Import Data



- Despite tariffs, PV modules and cells were imported at historically high levels in H1 2020.
 - 14.2 GW of PV modules were imported in H1 2020.
 - 1.3 GW of cells were imported in H1 2020.
 - Starting on 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-GW Ohio manufacturing facilities continued to ramp up production in H1 2020.
 - First Solar reported operating at 75% fleetwide capacity in late March and April, and 100% capacity in May, June, and July.
- The United States imported a little more than 250 MW of PV cells per month for the first 4 months of 2020, but imports dropped to 195 MW in May and 74 MW in June. With 6.8 GW of c-Si PV module assembly capacity, 1.3 GW of imported cells in H1 2020 implies a 45% utilization rate.

H1 2020 Module Imports by Tariff



- In H1 2020, 7.9 GW of imported PV modules did not report a tariff.
 - Historically most of these modules were thin-film, but in H1 2020, most of these modules (5.4 GW) were reported to be c-Si and exempt from the Section 201 duties—mostly from South Korea, Vietnam, Thailand, and Malaysia.
 - Most of these were likely bifacial modules, which were exempt in H1 2020, despite legal challenges. However, the administration is currently trying to reinstate the tariffs, which have thus far been blocked on procedural grounds by the U.S. trade court.
 - For approximately 0.6 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

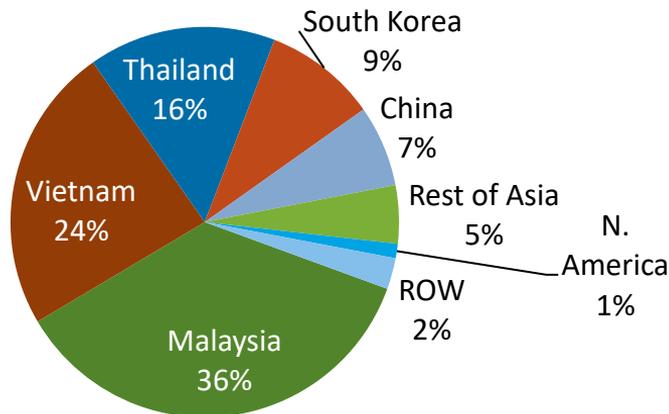
In H1 2020, Malaysia, Vietnam, Thailand, South Korea, and China represented 91% of PV *module* imports into the United States.

- In total, 96% of imports came from Asian countries.

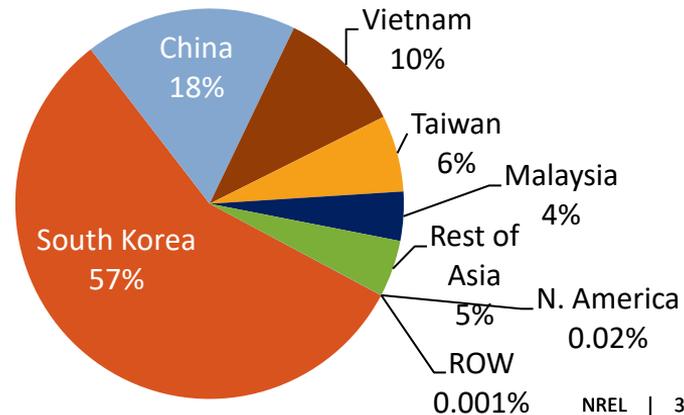
In H1 2020, South Korea represented more than 50% of PV *cell* imports into the United States, and China represented 18%.

- Korean companies Hanwha and LG announced the opening of 2.2 GW of U.S. module assembly capacity in the first half of 2019.
- Chinese companies China Sunergy, Seraphim Solar, and Jinko Solar announced more than 1 GW of U.S. module assembly.

H1 2020 U.S. Module Imports by Region (14.2 GW)



H1 2020 U.S. Cell Imports by Region (1.3 GW)



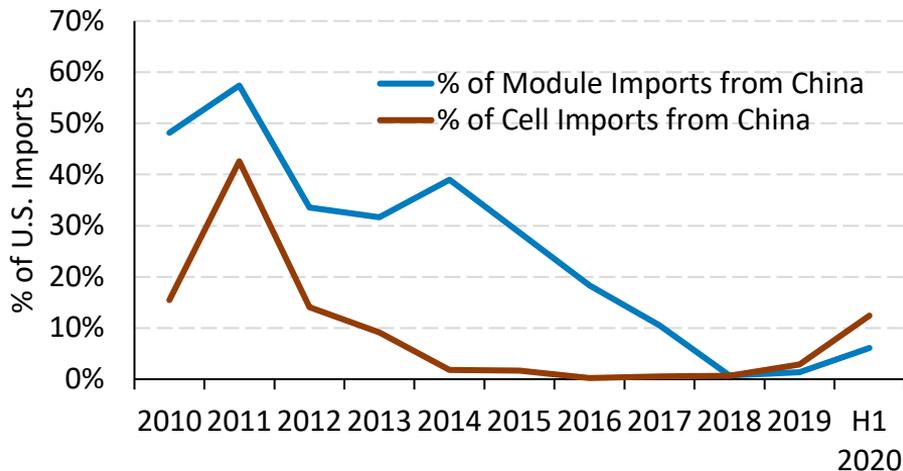
Note: Cell data uses HTS codes: 8541406030, 8541406025; module data uses codes: 8541406015, 8541406020, 8541406035
Sources: Imports, by value and MW: U.S. International Trade Commission, 2020.

Chinese PV Imports

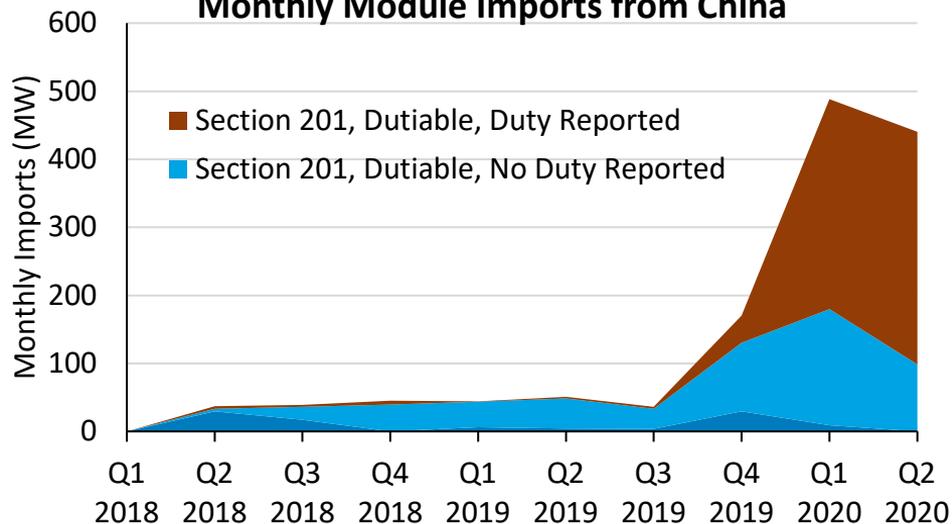
- Until late 2019, Chinese PV imports into the United States had decreased steadily over the decade.
 - Chinese PV cell imports fell first with tariffs introduced in 2012, followed by subsequent module tariffs in 2014.

- Since September 2019, U.S. module imports from China have increased dramatically.
 - The Section 201 bifacial exemption was enacted in June 2019 before imports took off.
 - China has a significant bifacial PV manufacturing capacity.
 - The administration signed an initial trade deal with China in January 2020 after imports took off.

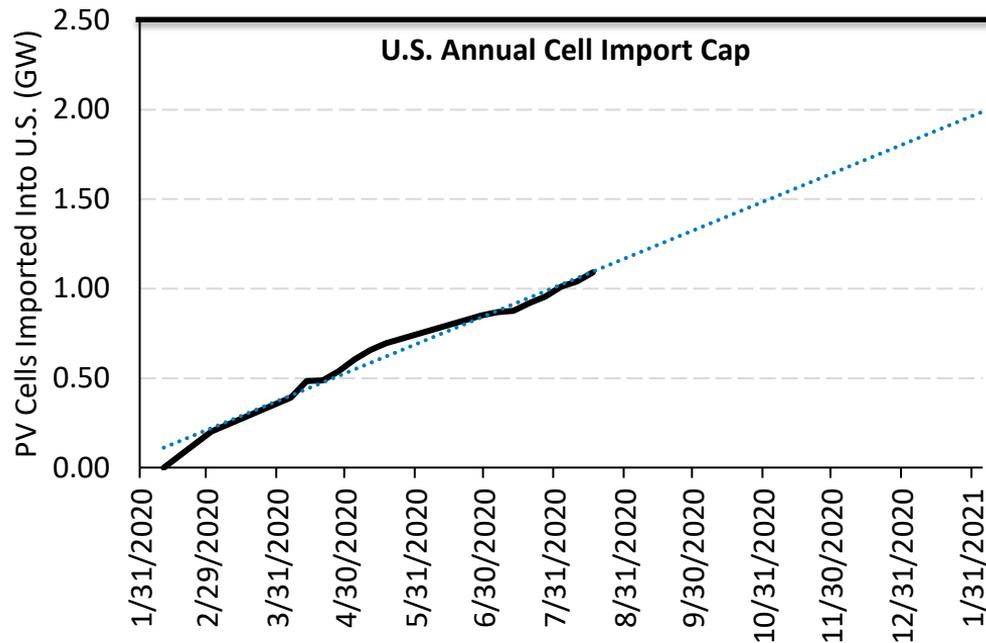
Percent of U.S. PV Imports from China



Monthly Module 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 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 but did not exceed the 2.5 GW PV cell quota.
- If the February–August 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.
- Approximately 15% of imported PV cells are reported as being exempt from the quota and are thus not included in figure.
 - IBC cells, bifacial cells, and cells from some developing countries are not subject to the tariffs.



1 Global Solar Deployment

2 CSP Deployment

3 U.S. PV Deployment

4 PV System Pricing

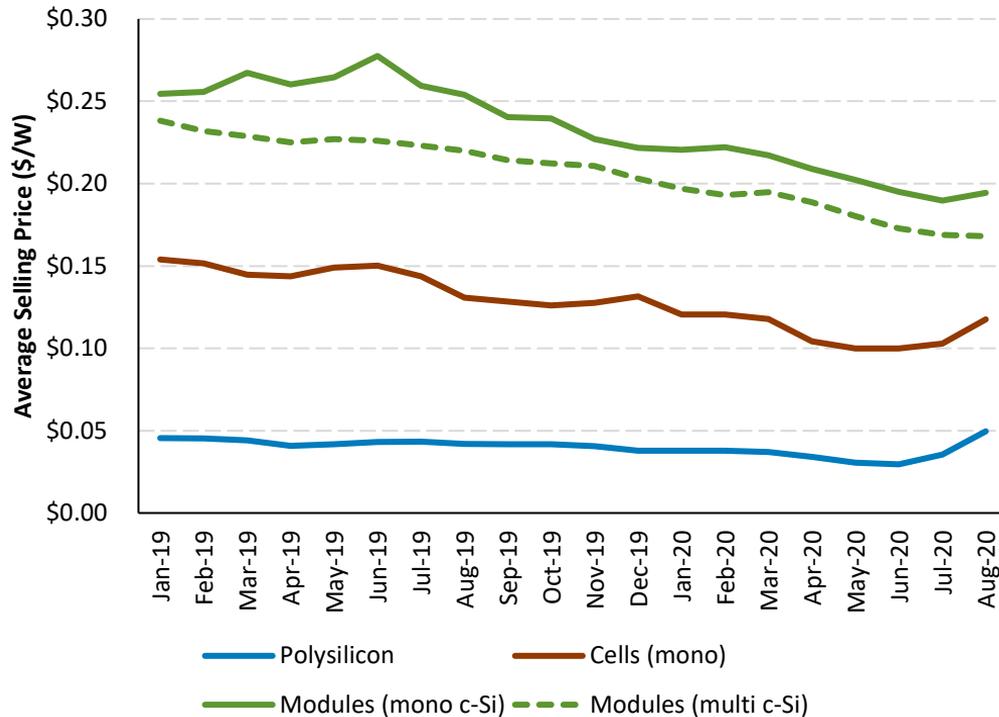
5 Global Manufacturing

6 **Component Pricing**

Market Activity

- **Global module and module-component prices continued their price declines through June; however, supply disruptions in the polysilicon industry have caused PV modules and components to increase in price in July and August 2020. 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.**
- **In Q4 2019, U.S. mono c-Si module prices fell, dropping close to their lowest recorded level, but they were still trading at a 71% premium over global module ASP.**

PV Value Chain Spot Pricing



- Global module and module-component prices continued their declines through June; however, supply disruptions in the polysilicon industry have caused PV module and component prices to increase in July and August 2020.
- 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.

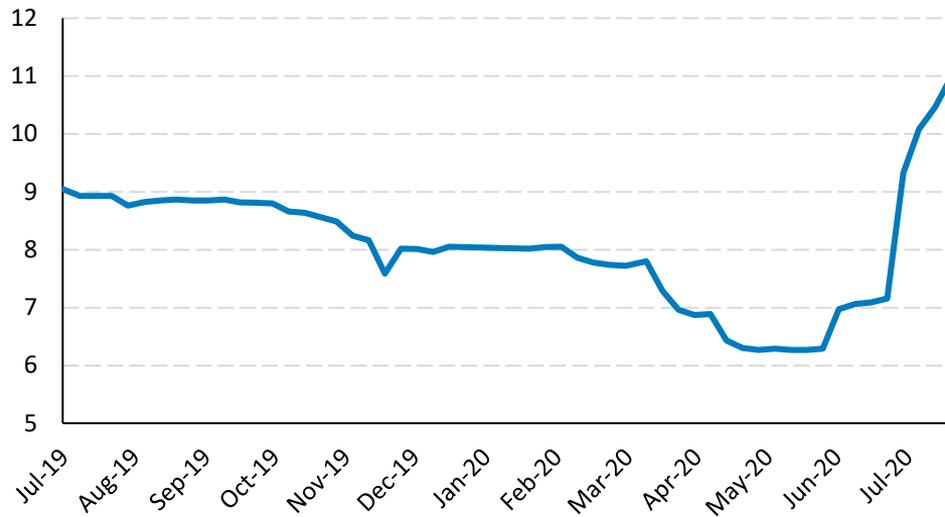
Source: BNEF Solar Spot Price Index (08/20/20).

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).

GCL Plant Explosion Leads to Increase in Poly Costs

- The spot price of polysilicon jumped almost 50% in July, and then another 18% in August, in large part due to an explosion at a GCL manufacturing plant in Xinjiang, China. GCL was the fourth largest producer of poly in 2019.
 - Poly prices had dropped more than 20% in H1 2020.

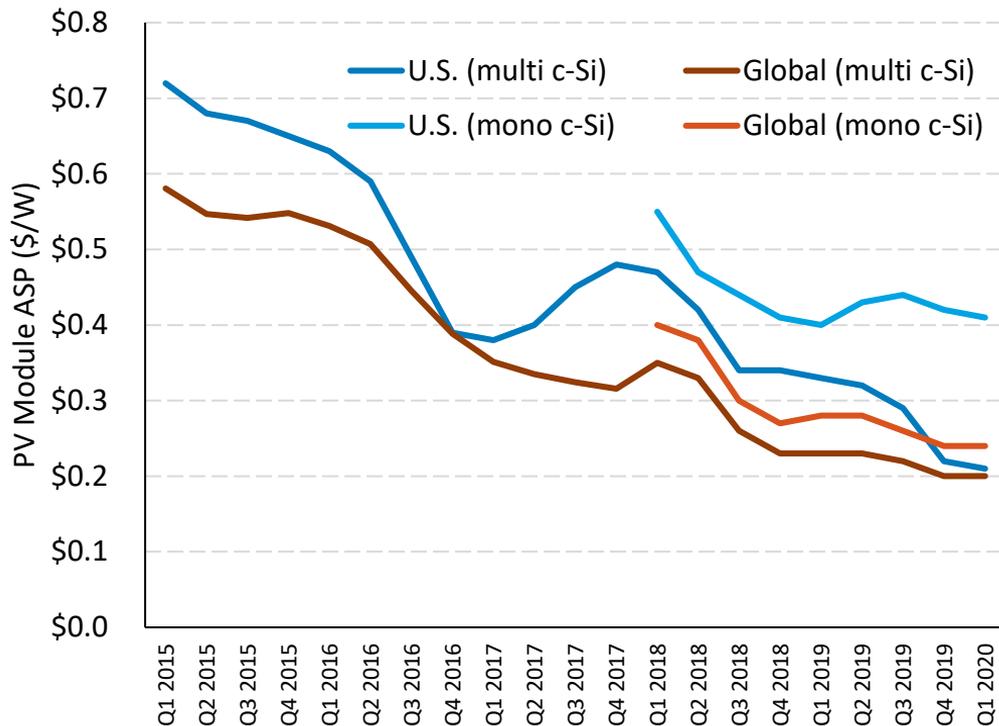
Polysilicon Spot Price (\$/kg)



Sources: Bloomberg (08/20/20); BNEF “Solar Spot Price;” Mercom (07/27/20; 08/03/20).

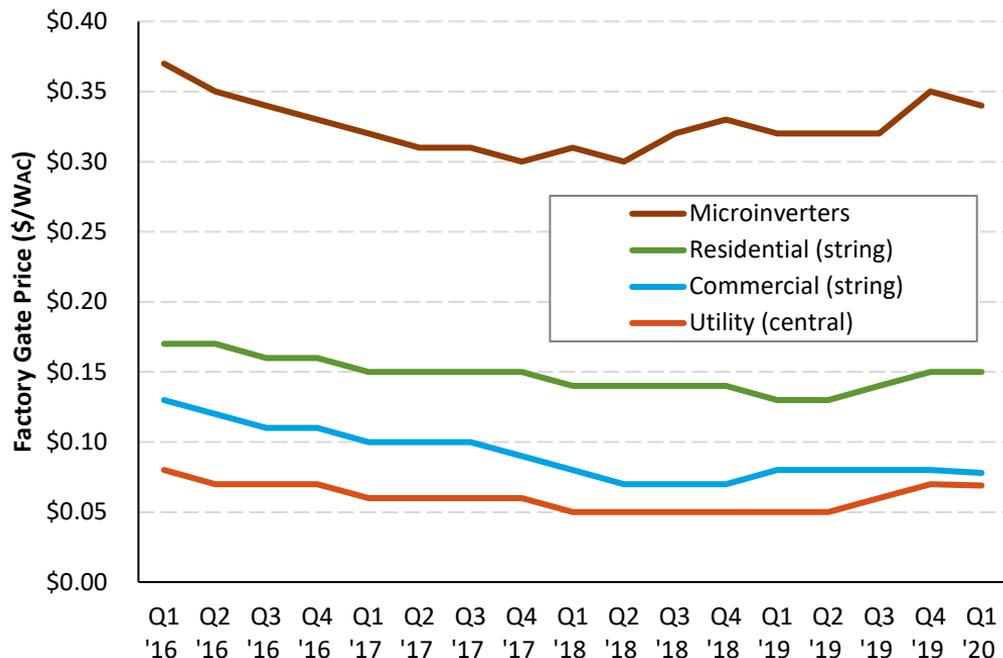
- Several polysilicon suppliers were already in the middle of their annual maintenance when the accident occurred, making the supply constraint more pronounced.
- In August 2020, Tongwei announced that flooding in China would force it to shut down 20,000 MT of polysilicon capacity.
- Roth Capital reported that the GCL facility suffered from four flash explosions on a Sunday and then a fifth the next day.
 - The suspected cause was overpressure in the rectification and boron removal filter, leading to a leak of trichlorosilane gas.
- The explosion was reported to take 50,000 MT of polysilicon production offline—or 10% of global production capacity.
 - GCL was also planning on increasing production capacity by 20,000 MT later this year, which is likely to be delayed.
 - Bloomberg reported that a person with knowledge of this situation said it will take a month make the repairs and start production.
- The price increase in polysilicon may be passed on to other solar components, such as wafers, cells, and modules.

Module Average Selling Price: Global versus United States



- In Q1 2020, U.S. mono c-Si module prices fell, dropping close to their lowest recorded level, but they were still trading at a 71% premium over global ASP.
 - U.S. multi c-Si module prices dropped precipitously due to significant lack of demand, very close to global pricing.
 - Bifacial modules are trading a few cents below mono c-Si in the United States due to a temporary injunction on the Section 201 tariffs.

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 Q/Q.



1 Global Solar Deployment

2 CSP Deployment

3 U.S. PV Deployment

4 PV System Pricing

5 Global Manufacturing

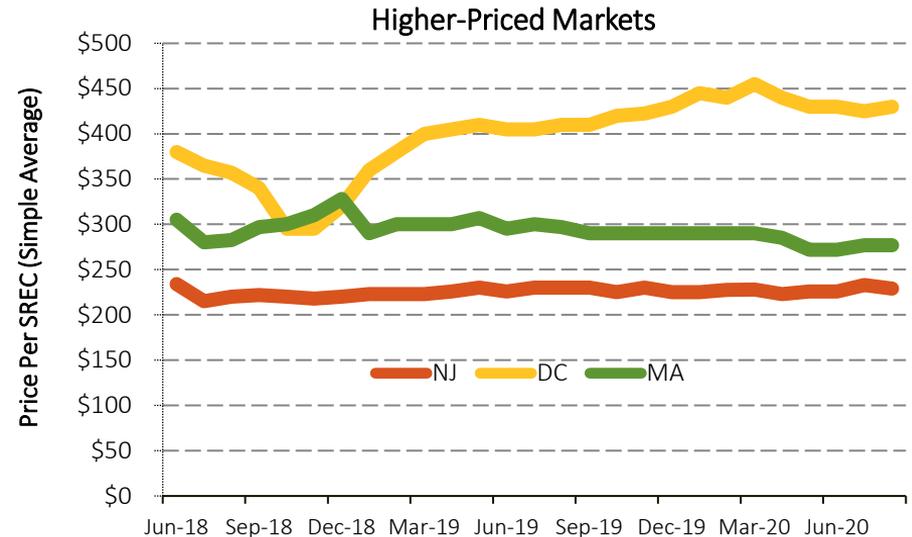
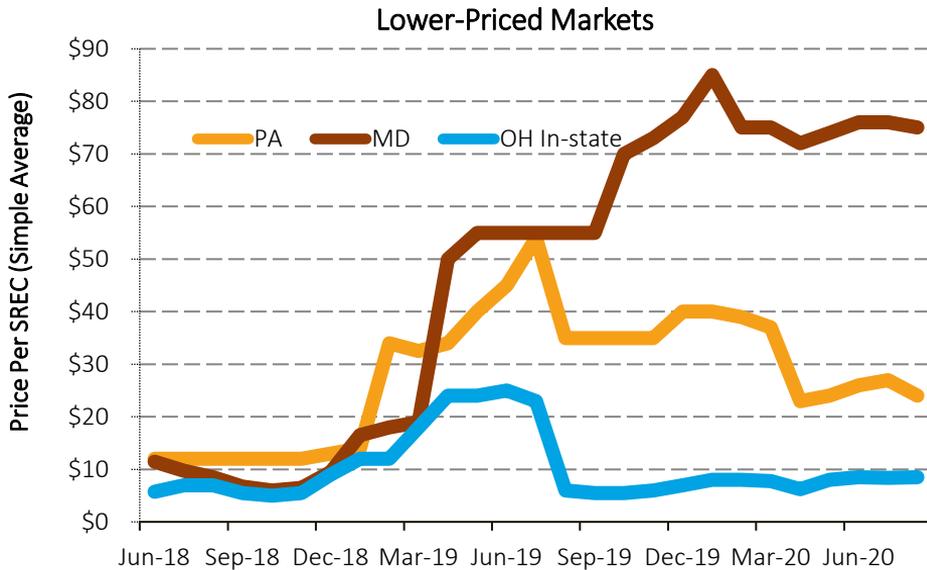
6 Component Pricing

Market Activity

- 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.
- **While 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.**
 - **Analysts attribute these gains to good financial performance from companies, driven by stronger than expected global demand, despite the pandemic.**

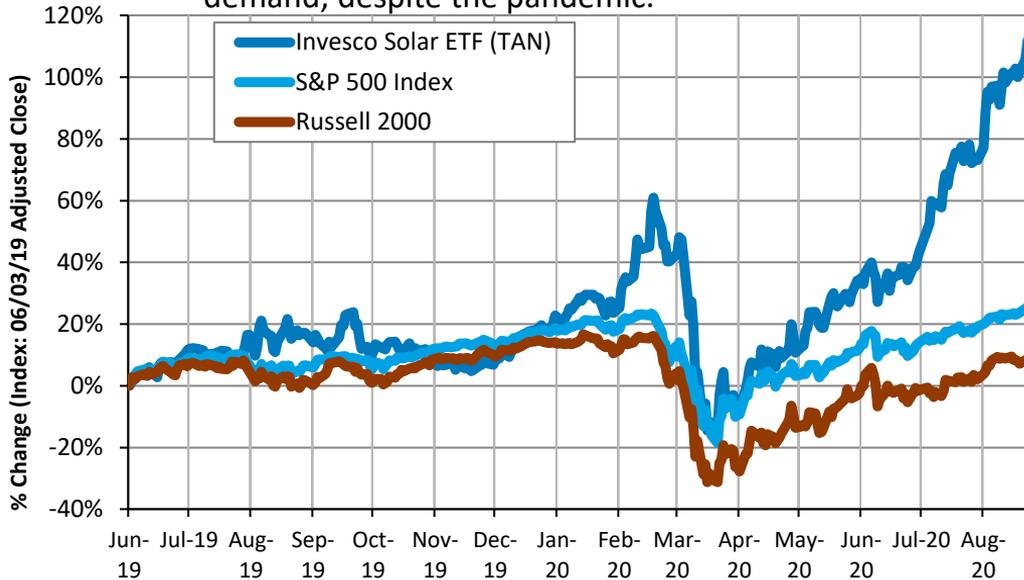
SREC Pricing

- 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.
 - There could be a change in spot price toward the end of compliance years, should electric suppliers need significantly less (or more) SRECs than expected.



Stock Market Activity

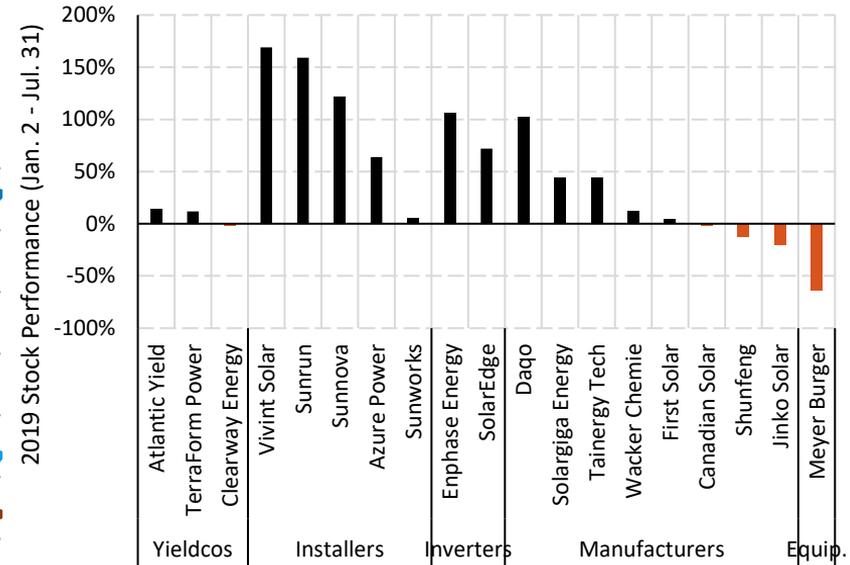
- Although solar stock gains made in the beginning of 2020 were erased with the downturn in the market in March, they have significantly outperformed the rest of the market since.
 - Analysts attribute these gains to good financial performance from companies, driven by stronger than expected global demand, despite the pandemic.



Source: Stock market: Yahoo Finance (08/27/20) [Barron's \(August 4, 2020\)](#).

- Not all sectors or companies fared the same, with U.S.-focused installers and MLPE companies' stocks performing very well.

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.

Thank You

www.nrel.gov

NREL/PR-6A20-77772

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



List of Acronyms and Abbreviations

• ASP	average selling price	• MLPE	module-level power electronics
• BNEF	Bloomberg New Energy Finance	• Mono c-Si	monocrystalline
• CdTe	cadmium telluride	• Multi c-Si	multicrystalline
• C-Si	crystalline silicon	• MW	megawatt
• CSP	concentrating solar power	• MWh	megawatt-hour
• DC	direct current	• NEM	net energy metering
• DPV	distributed PV	• Poly	polysilicon
• EIA	U.S. Energy Information Administration	• PPA	power purchase agreement
• ETF	exchange traded fund	• PV	photovoltaic
• FERC	Federal Energy Regulatory Commission	• PURPA	Public Utility Regulatory Policies Act
• G&A	general and administrative expenses	• R&D	research and development
• GOGLA	Global Off-Grid Lighting Association	• Q	quarter
• GW	gigawatt	• S&P	Standard and Poor's
• H1	first half of year	• SEIA	Solar Energy Industries Association
• H2	second half of year	• SG&A	selling, general and administrative expenses
• IBC	interdigitated back contact	• SHS	solar home system
• IRENA	International Renewable Energy Agency	• SMART	Solar Massachusetts Renewable Target
• ISO-NE	ISO – New England	• SREC	solar renewable energy certificate
• ITC	investment tax credit	• TAN	Invesco Solar ETF
• kg	kilogram	• W	watt
• kW	kilowatt	• y/y	year over year
• kWh	kilowatt-hour	• YTD	year to date
• LCOE	levelized cost of energy		
• LMI	low-and-moderate income		