

# Q4 2019/Q1 2020 Solar Industry Update

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# Executive Summary

- At the end of 2019, global PV installations reached 627 GW<sub>DC</sub>, an annual increase of 115 GW<sub>DC</sub> from 2018.
  - In 2019, the leading markets in terms of annual deployment were China (30 GW<sub>DC</sub>), the U.S. (13 GW<sub>DC</sub>), and India (10 GW<sub>DC</sub>).
- Before the spread of COVID-19, analysts had projected that global PV demand would grow 14%–22% from 2019 to 2020—now they expect demand to remain flat in 2020.
- In 2019, approximately 681 MW of CSP was installed globally in Israel, China, South Africa, and Kuwait.
- The United States installed 13.4 GW<sub>DC</sub> of PV in 2019 and 5.9 GW<sub>DC</sub> in Q4, and cumulative capacity reached 76.0 GW<sub>DC</sub>.
- Since 2016, PV has represented approximately 30% of new U.S. electric generation capacity, with an estimated 34% in 2019.
- In 2019, solar represented 5.4% of net summer capacity and 2.6% of annual generation in the United States.
  - California leads with almost 20% of generation in 2019, representing a 52X increase from 2010 (0.4%).
- At the end of 2019, there were approximately 2.3 million residential PV systems in the United States.
- The United States installed approximately 1.1 GWh (0.5 GW) of energy storage onto the electric grid in 2019—up 43% y/y and 22X annual installations in 2013.
- From H2 2018 to H2 2019, EnergySage reported a 4% reduction in the median gross costs of a residential system to \$2.89/W<sub>DC</sub>.
- In a select dataset of utility-scale PV systems (109 projects totaling 3.3 GW<sub>AC</sub>) owned by 20 regulated utilities, the median system price installed in 2019 was \$1.34/W<sub>AC</sub> (\$0.89/W<sub>DC</sub>)—relatively flat y/y.
- In 2019, global PV shipments were approximately 123 GW—an increase of 39% from 2018.
- In 2019, 62% of global PV shipments were mono c-Si technology—a level not seen since the early 80s.
- Global module and module-component prices continued their price declines in the first five months of 2020, with BNEF reporting mono c-Si modules down 8% to \$0.21/W, multi c-Si modules down 11% to \$0.19/W, cells down 24% to \$0.10/W and poly down 18% to \$6.5/kg.
- In Q4 2019, U.S. mono c-Si module prices fell, dropping close to their lowest record levels, but they were still trading at a 75% premium over global module ASP.



**1** Global Solar Deployment

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**2** CSP Deployment

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**3** U.S. PV Deployment

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**4** PV System Pricing

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**5** Global Manufacturing

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**6** Component Pricing

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**Market Activity**

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## 1 Global Solar Deployment

## 2 CSP Deployment

## 3 U.S. PV Deployment

## 4 PV System Pricing

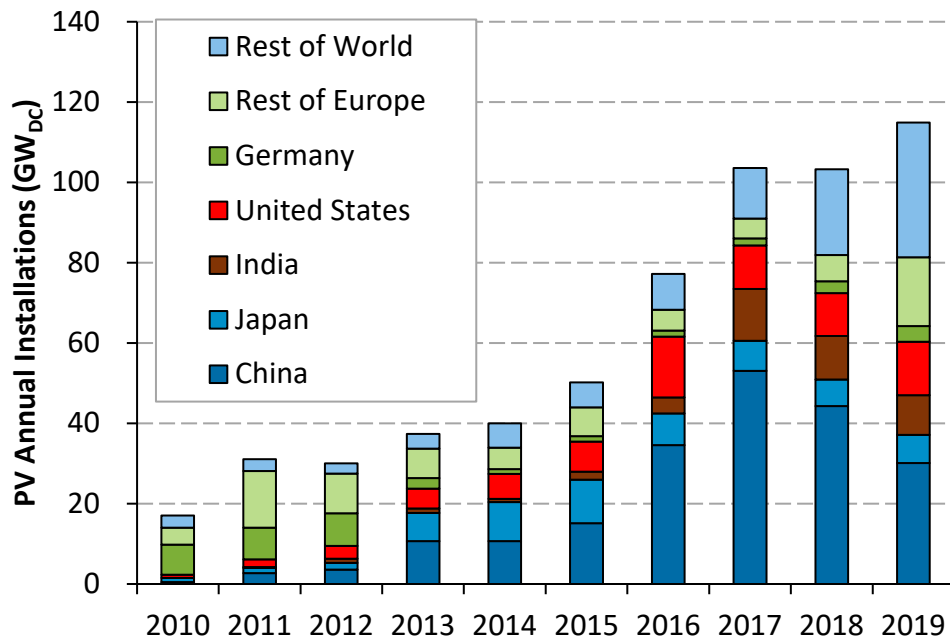
## 5 Global Manufacturing

## 6 Component Pricing

## Market Activity

- **At the end of 2019, global PV installations reached 627 GW<sub>DC</sub>, an annual increase of 115 GW<sub>DC</sub> from 2018.**
  - In 2019, the leading markets in terms of annual deployment were China (30 GW<sub>DC</sub>), the United States (13 GW<sub>DC</sub>), and India (10 GW<sub>DC</sub>).
- **Before the spread of COVID-19, analysts had projected that global PV demand would grow 14%–22% from 2019 to 2020—now they expect demand to remain flat in 2020.**
- **The IEA estimates that in 2019, 3% of global electricity generation came from PV.**
  - Germany, Japan, and India’s PV generation was between 8%–9% of total electric generation.

# Global Annual PV Capacity Additions by Country



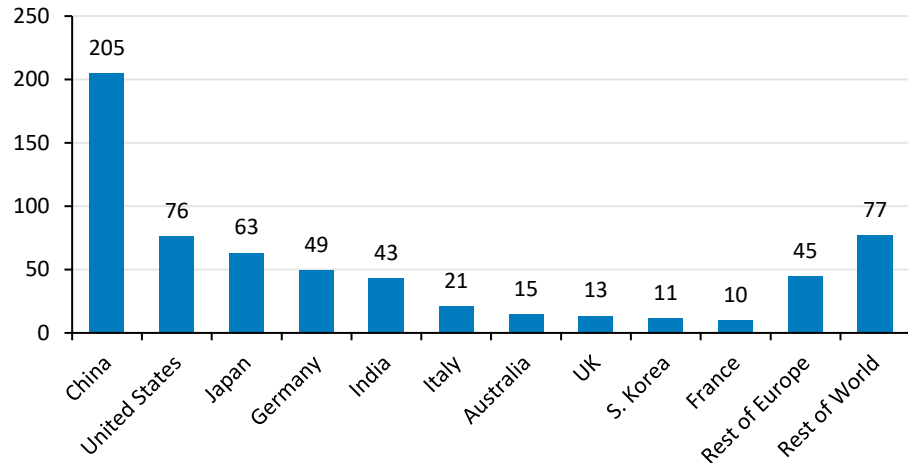
- From 2010–2019, global PV capacity additions grew from 17 GW to 115 GW.
- European markets led in the beginning of the decade, but PV growth transitioned to Asia.
  - At the end of 2019, 57% of cumulative PV installations were in Asia compared to 22% in Europe and 15% in the Americas.
  - The United States is the country with the second largest cumulative installed PV capacity.
  - There has also been a recent surge of ROW installations, indicating the “globalization” of PV.

# Top PV Markets

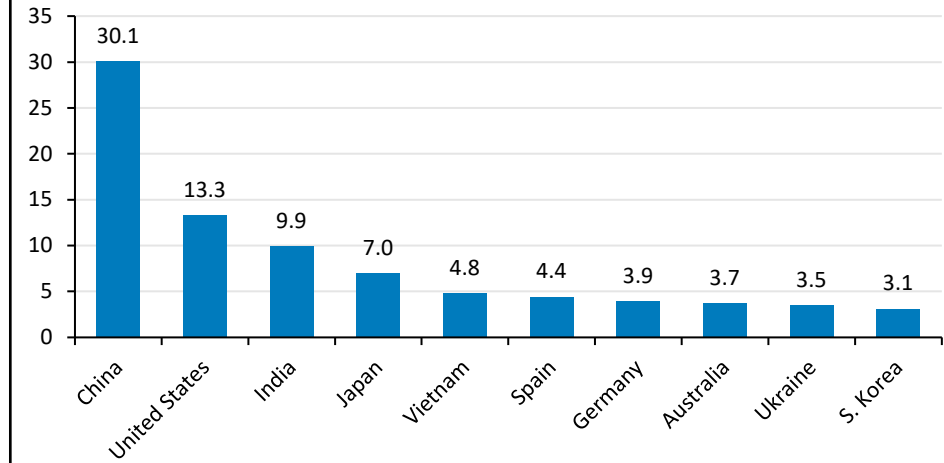
- At the end of 2019, global PV installations reached 627 GWDC, an annual increase of 115 GWDC from 2018.
- The leading five markets in cumulative and annual PV installations at the end of 2019 were China, the United States, Japan, Germany, and India.

- While China is still by far the largest PV market, its 2019 share of global PV installations (26%) was at its lowest since 2012.
- In 2019, the United States was the country with the second-largest PV market in terms of both cumulative and annual installations.

## Cumulative PV Deployment - 2019 (627 GW)



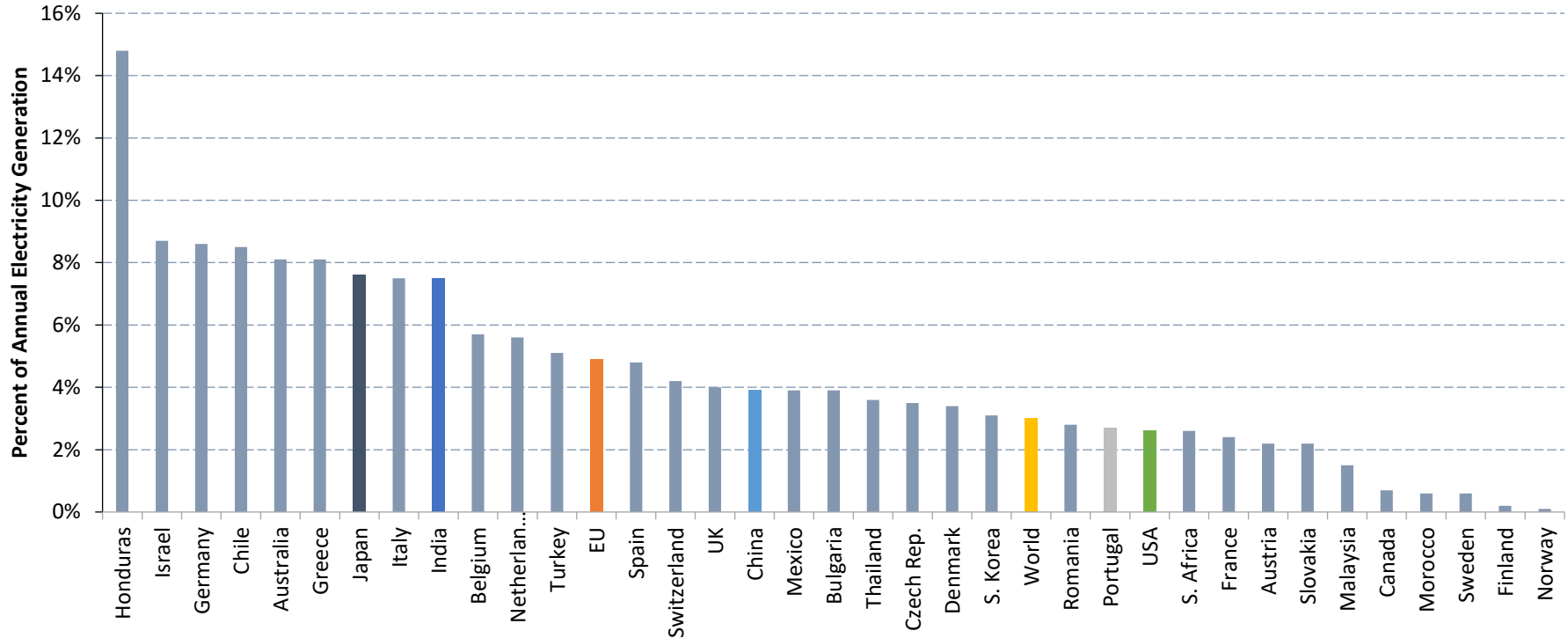
## Annual PV Deployment - 2019 (115 GW)



# Global PV Penetration

- The IEA estimates that in 2019, 3% of global electricity generation came from PV.

- The United States, despite being one of the leading PV markets, is below this average in terms of PV penetration with 2.6%.
  - If California were a country, its PV penetration would exceed Honduras.

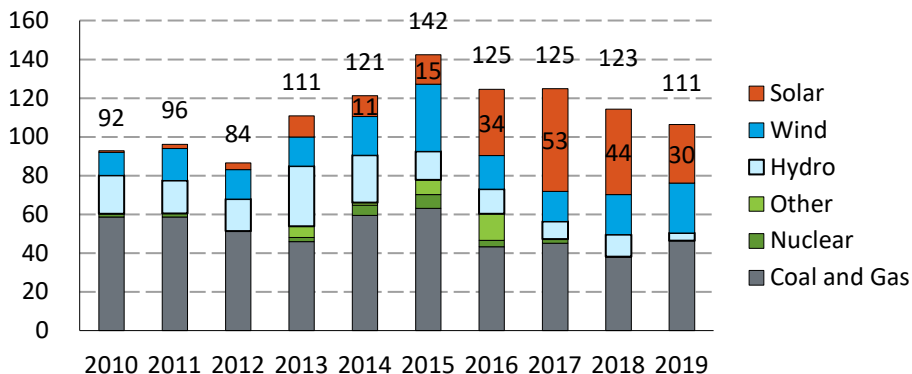


# Chinese Generation Capacity Additions by Source

- In 2019, solar contributed 27% to new generation capacity in China (30.1 GW) and 10% of cumulative capacity (205 GW).
  - 2019 was the third straight year that wind and solar contributed more than half of all new electric generation in China (51%); however, 2019 was also the second year of a decline in combined new capacity additions.
  - Chinese annual electric generation capacity additions have averaged 4–6 times greater than additions by the United States for the past 10 years.

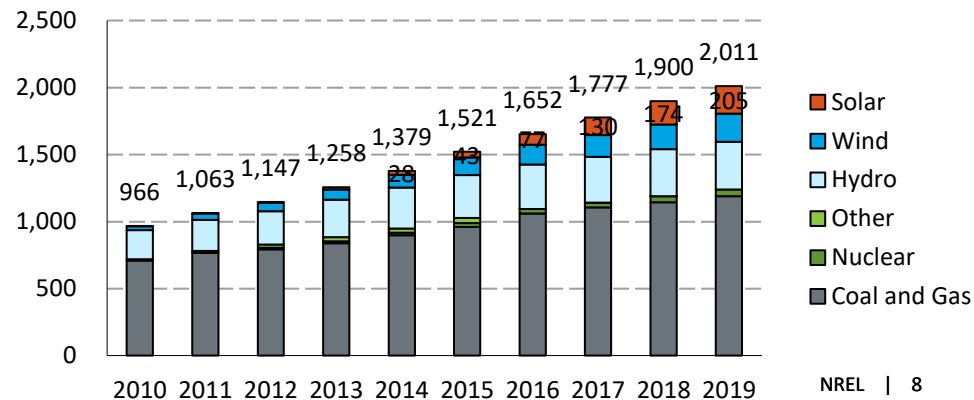
- As China grows its electricity infrastructure, it has rapidly incorporated non-carbon sources of electricity generation.
  - Since 2010, China has more than doubled its installed electric generation capacity, and at the same time, it reduced the percentage of total coal and gas capacity from 74% to 59%.
  - From 2010 to 2019, new non-carbon generation capacity as a percentage of total new capacity increased from 37% to 58%.

Annual Capacity Additions (GW)



Source: China Electric Council, accessed (2017, 2018, 2019, 2020).

Cumulative Capacity (GW)





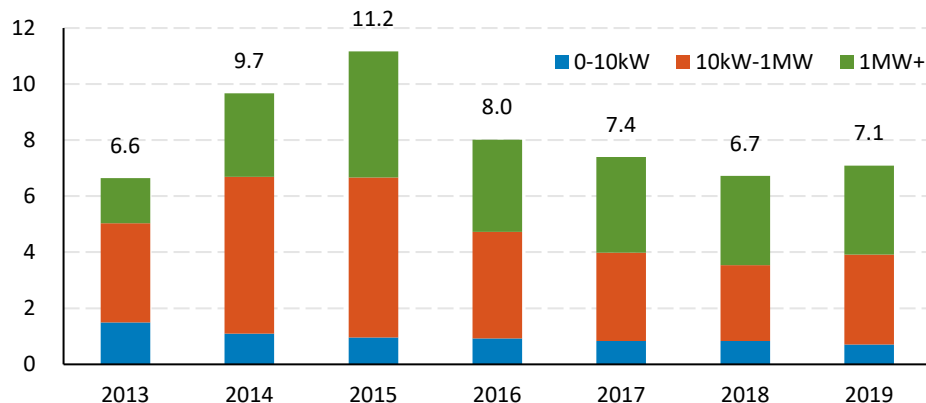
# Chinese Market Update

- China installed 30.1 GW of PV in 2019—17.9 GW were large-scale, and 12.1 GW were distributed PV projects, bringing cumulative Chinese PV capacity to 205 GW.
  - 12 GW were installed in December—more than any other country’s annual total, except the United States.
  - 2019 PV installation levels were below their 2016–2018 levels.
- In May, a Chinese agency announced there was room in 2020 to increase annual renewable installations by 52% above the amount added in 2019.
  - COVID-19 affected Q1 2020 Chinese installations; however, March installations were at historical highs as the market recovered and several projects tried to meet a March 31 deadline for the 2019 national auction.
- China has traditionally spurred PV growth through a FiT but is shifting large systems in many areas to auctions.
  - FiTs have been a burden to the country and many FiT payments have been delayed, hurting project owners.
- The province with the second largest amount of PV in China—Jiangsu—temporarily banned distributed PV projects from selling power back into the grid as it faces difficulty absorbing renewables onto its grid.

# Japanese Market Update

- IEA reports that approximately 7.1 GWDC of PV were installed in Japan in 2019, an increase of 5%—most of the growth came from systems between 10 kW and 1 MW.
  - Falling FiT rates for smaller systems, and interconnection and citing issues for large systems, has shrunk the Japanese PV markets of small-scale and large-scale PV systems since 2015.

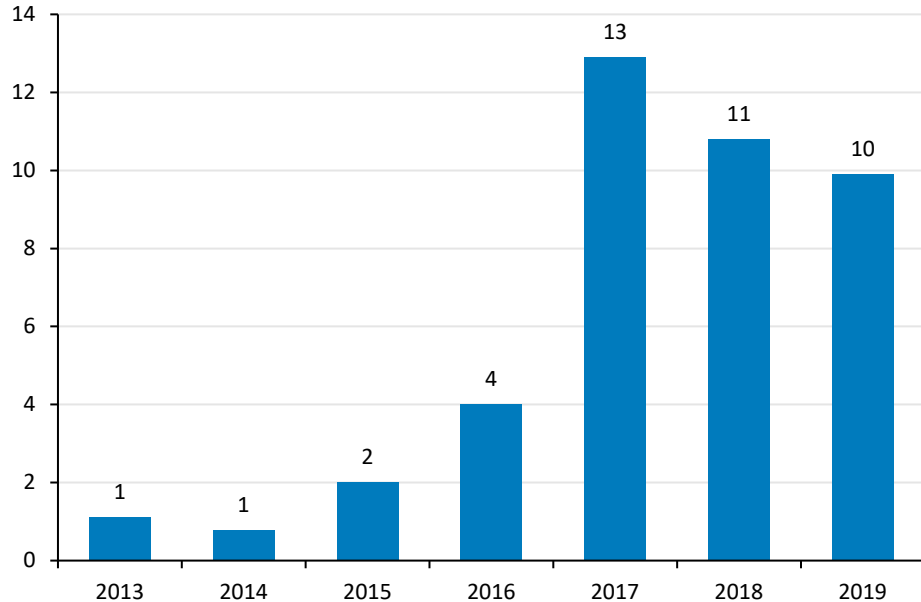
Annual Japanese PV Deployment (GWDC)



- In 2020, residential solar and battery installations are the sectors most affected by COVID-19 as door-to-door sales are limited and households are hesitant to make big purchases.
  - Utility-scale PV has been moderately affected by China-dependent supply chain disruptions, with racking deliveries delayed a month, and permitting meetings postponed.
- Japan's fifth PV auction in January 2020 was heavily undersubscribed as projects face stricter grid connection standards and difficulty finding suitable land.
  - The volume-weighted average bid of \$0.11/kWh was the lowest on record, although it's still 166% higher than winning bids in Germany.
  - Two more auctions scheduled this year will also include smaller systems for the first time (250 kW–500 kW), which may increase bids.
- In February 2020, Japan set preliminary FiT rates starting in April. Systems under 10 kW are set to receive \$0.19/kWh (down from \$0.36/kWh in 2013) and larger systems are set to receive \$0.11/kWh–\$0.12/kWh.

# Indian Market Update

Annual PV Deployment (GW<sub>DC</sub>)

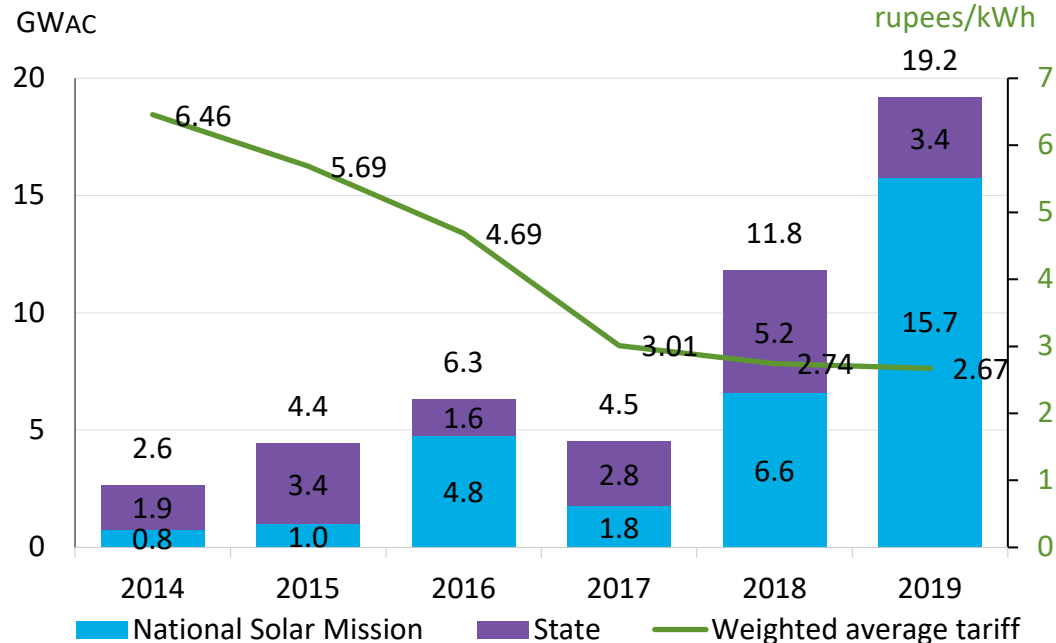


Sources: Mercom India (February 2020), IEA “PVPS Snapshot 2020;” BNEF.

- India installed 9.9 GW of PV in 2019, a decline of 8% y/y and 23% from its peak in 2017.
  - Large-scale projects accounted for 85% of 2019 installs and 88% of cumulative PV installations.
  - Mercom attributes the difficulties in the large-scale PV market to come from: contracting and contract renegotiations, financing, infrastructure availability, and power curtailment.
  - Annual rooftop PV installations declined for the first time in five years due to the slowdown in the Indian economy and the difficulty of installers to find financing, caused by the NBFC crisis.
- COVID-19 has significantly reduced analyst projections of India’s 2020 PV additions, as a lockdown has restricted worker movement, and some projects will fail to commission before monsoon season halts work.

# Indian Market Update

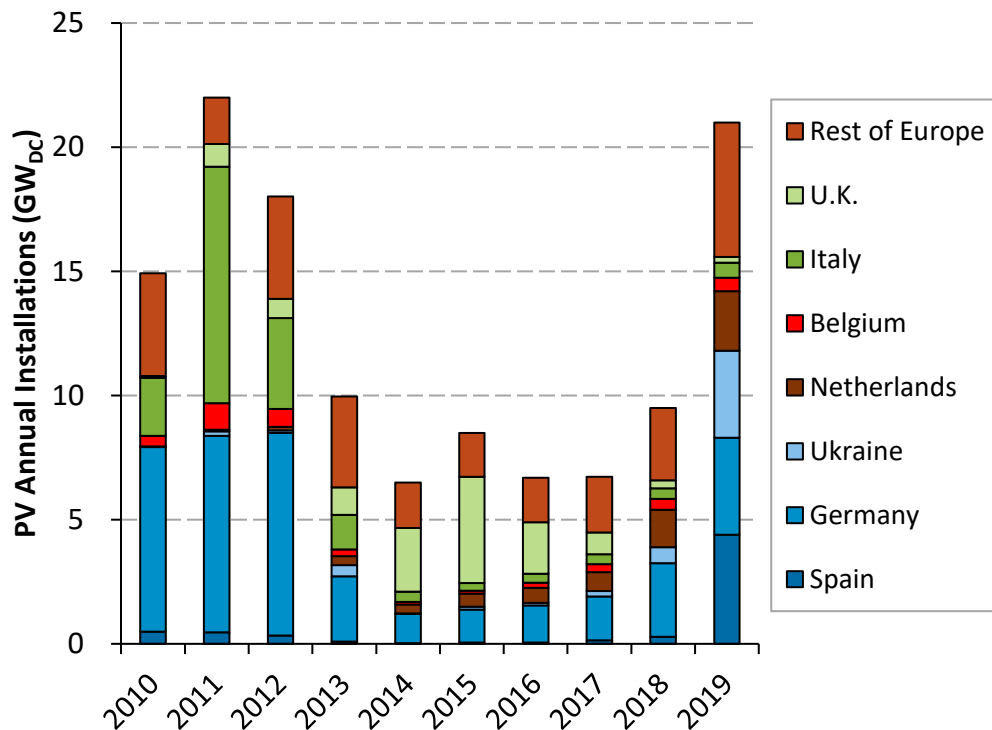
- In 2019, India awarded a record 19.2 GWAC of PV capacity at a record low weighted-average price of 2.67 rupees/kWh.



Source: BNEF, "India's Solar Auctions: Bigger and Cheaper." March 24, 2020.

- Not all 2019 auctions in India were fully subscribed as some developers did not participate in ones viewed with unfavorable terms.
- Many of the awards occur during large federal auctions as the federal government pushes to meet its 2022 target of 60 GWAC (from 36 GWAC at the end of 2019).
  - These auctions attracted large IPPs and low tariffs.
  - 67% of the auctions were above 500 MW, and 96% were greater than or equal to 100 MW.
- The Indian government is moving away from what it calls "solar parks"—large auctions where the government picks a piece of land, divides it into plots, provides basic roads, water supply and builds the transmission grid up to the park periphery. Finding huge areas of contiguous land has become an issue, and developers found that facilities were not always worth the high lease costs.
- While the capacity-weighted average price was at a record low, the lowest tariff in 2019 was higher than the lowest tariff during the previous two years.
  - BNEF attributes this to currency depreciation, policy uncertainty, and fears of increased payment delay.

# European Market Update

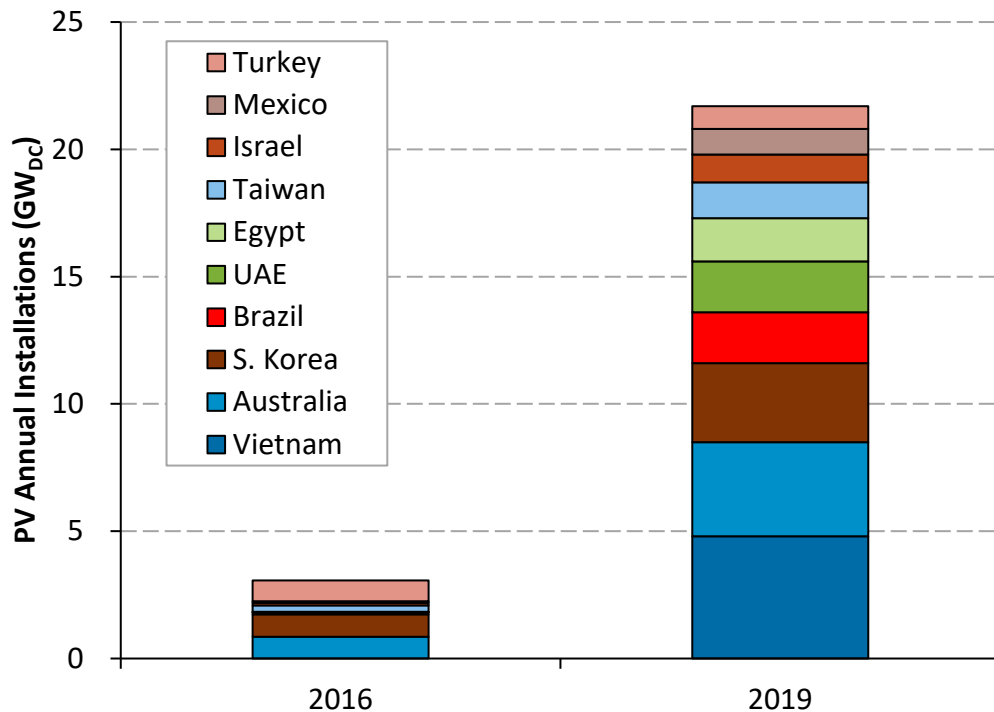


- After a few years of lower growth, as countries tried to avoid feed-in tariff booms, the European market accelerated again in 2019, as countries seek to meet their 2020 renewable energy targets.
  - Many countries are using solar auctions and export tariffs for rooftop solar and there is several GW of unsubsidized solar being built in Spain.
- In 2019, Europe installed 21 GW of PV (16 GW in the EU). This represents a ~121% increase from 2018 annual installations in Europe.
- While a few countries—Spain, Germany, Ukraine, and the Netherlands—accounted for roughly 75% of the growth in Europe in 2019, many other countries increased their annual PV installations.

# European Market Update (Spain, Germany, and Ukraine)

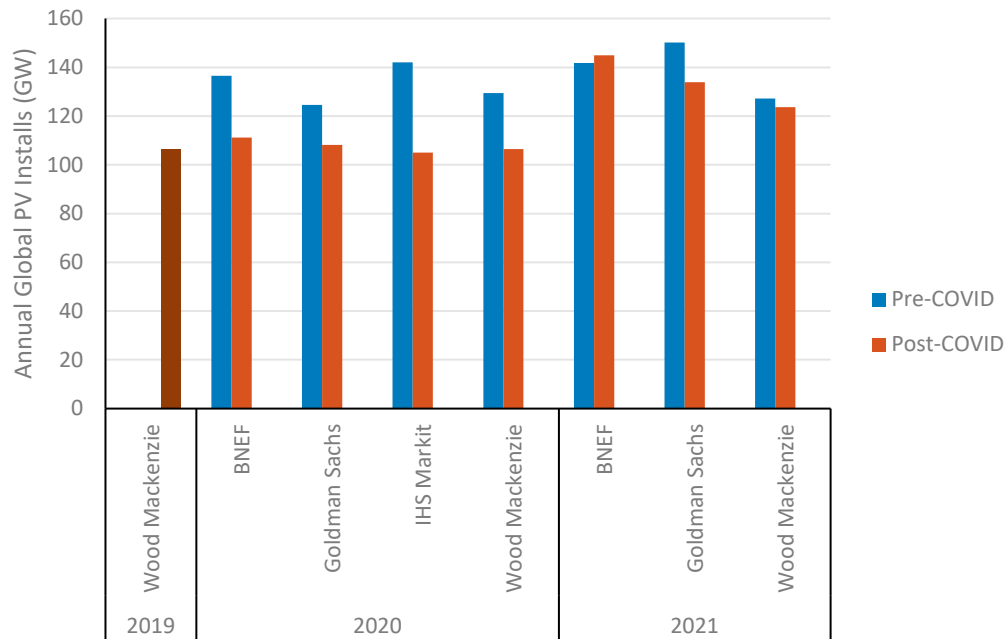
- For the first time since 2008, Spain was the largest PV market in Europe, installing 4.4 GW in 2019.
  - The main driver of 2019 installations in Spain was its 2017 auctions that awarded approximately 4 GW. Spain also has a growing pipeline of solar projects with PPAs, which are selling into the wholesale markets.
- Germany installed 3.9 GW in 2019, a 32% increase y/y for its fifth straight year of market growth and its biggest year since 2012 when it was the global leader. Analysts attributed the growth to falling panel prices and increased electricity costs.
  - In May 2020, Germany eliminated its 52 GW solar incentive cap, which it would have hit sometime this year.
- Thanks to an attractive FiT, Ukraine installed approximately 3.5 GW of PV in 2019—nearly tripling its PV capacity.
  - The Ukrainian government has drafted a ‘voluntary’ scheme in which owners will accept a 17% lower FiT in exchange for a five-year extension to the original 10-year rate. If they don’t accept, the change may be much harsher. The measure would also apply to another 6.5 GW of PPAs signed before 2020.
  - In addition to Ukraine in Eastern Europe, Hungary installed 0.9 GW and Poland installed 0.8 GW in 2019.
- In 2019, the Netherlands installed 2.5 GW of PV, up 66% from 2018.
  - The Netherlands has a tender program for ground-mounted and floating solar plants, and a strong net metering program; 40% of 2019 installations came from rooftop applications.

# PV Growth from Other Countries



- IEA estimates that approximately 29% of 2019 annual PV installations came from countries outside of the largest five markets—up from 12% in 2016.
- Within this group, the top 10 countries, shown in the graph to the right, grew their annual capacity additions over 600% from 2016 to 2019.

# Change in Global Projections from COVID-19



- Before the spread of COVID-19, analysts had projected that global PV demand would grow 14%–22% from 2019 to 2020.
- Analysts revised 2020 global projections over the past month to be 13%–19% below previous predictions, which would keep global demand relatively flat.
- Most analysts see demand rebounding in 2021 to approximately the same values as they had previously predicted, or significantly above 2019 installations.





**1** Global Solar Deployment

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**2** **CSP Deployment**

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**3** U.S. PV Deployment

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**4** PV System Pricing

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**5** Global Manufacturing

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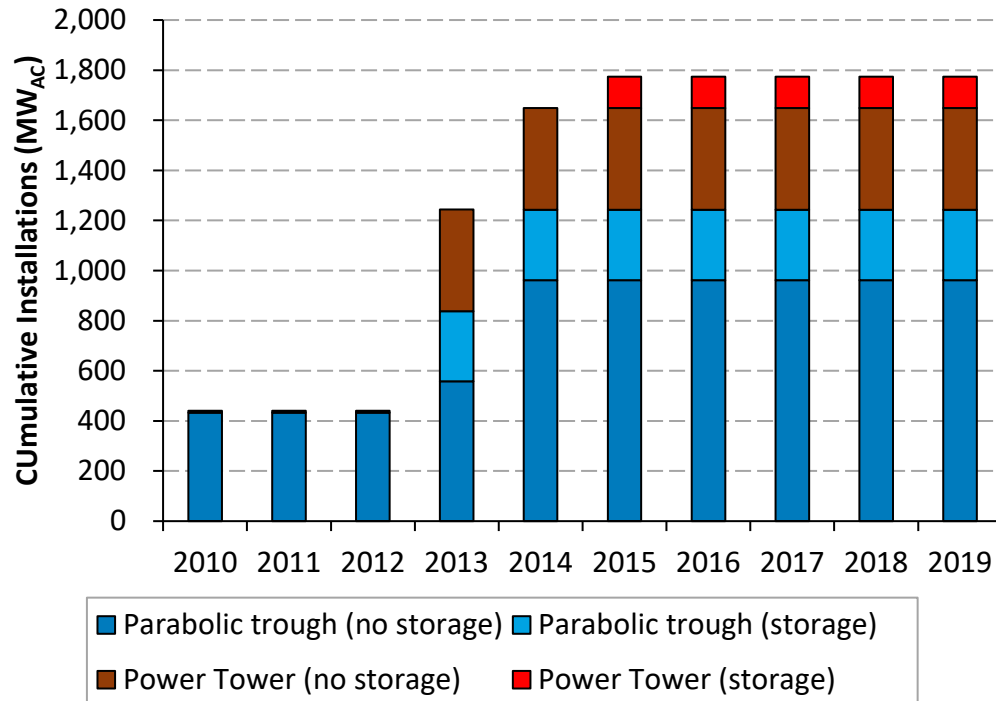
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Market Activity

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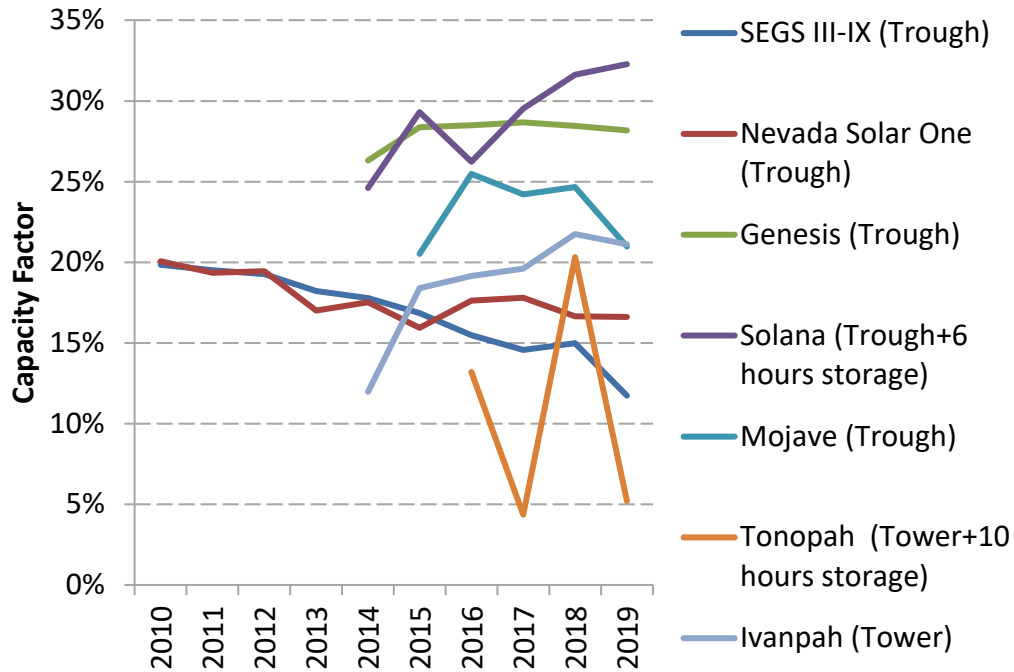
- In 2019, approximately 681 MW of CSP was installed globally in Israel, China, South Africa, and Kuwait.
- In the near future, CSP projects are expected in Chile and the Middle East, with significantly more planned in China and the Middle East in the longer term.
- It took a few years to optimize the operation of the five U.S. CSP plants brought online from 2013 to 2015, and now four of them generally perform better than when they began operation.

# U.S. CSP Installed Capacity, 2010–2019



- From 2012 to 2015, U.S. CSP (or solar thermal) installations more than quadrupled.
  - This growth was largely due to a series of projects supported through the U.S. Department of Energy’s Loan Program Office.
  - Most of these projects utilized new power tower designs or utilized storage (or both).
- While there were other CSP projects under development in the United States from 2010–2019, due to the rapid decline in PV-system price, all of these other U.S. CSP projects were either canceled or shelved.

# U.S. CSP Project Generation Performance, 2010–2019



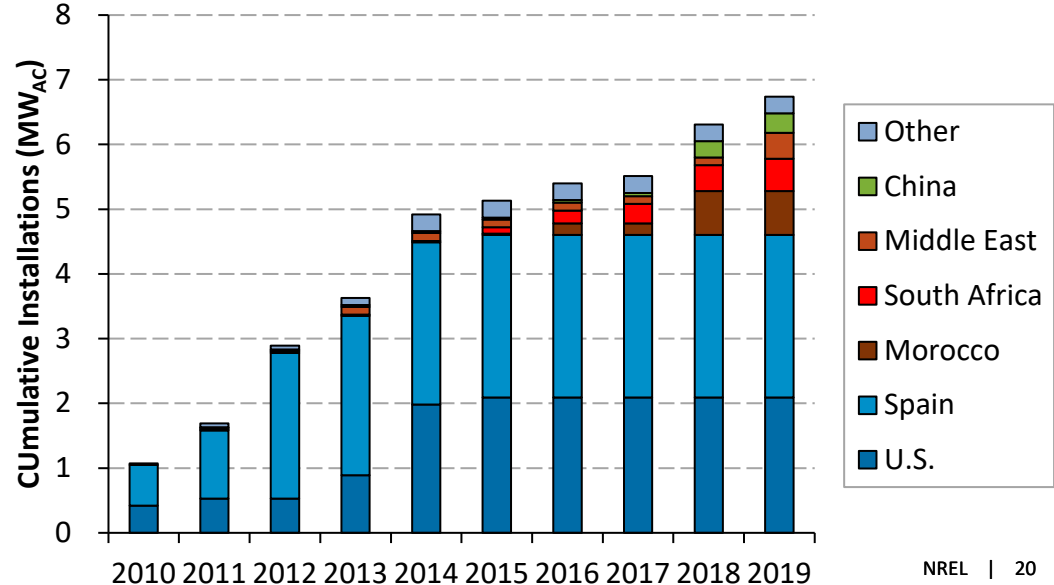
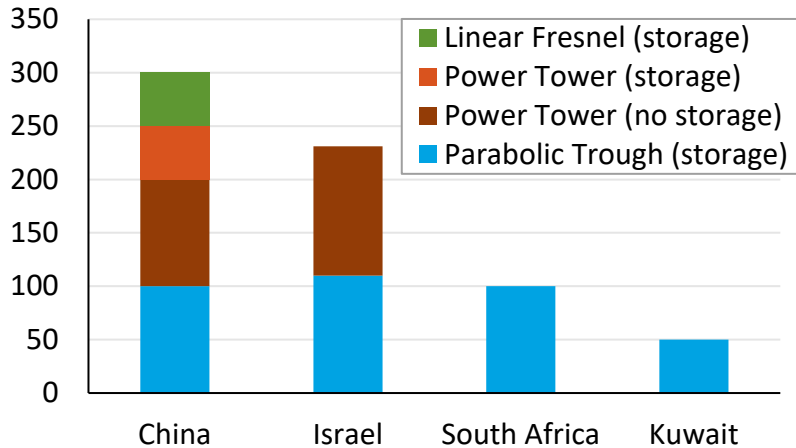
- While it took a few years to optimize the operation of the five U.S. CSP plants brought online from 2013–2015, four of them now generally perform better than when they began operation.
  - Annual weather variation also caused some of the differences in annual production.
  - Tonopah continues to have challenges four years after it was placed in service. It did not produce power for the last 8+ months of 2019 and for seven months in 2017.
- Absolute capacity factor is not necessarily the best metric for performance as plants can be designed and operated differently.
  - The capacity factors of the SEGS plants have decreased over time as the PPAs of these plants have expired and they have shifted to merchant production.

# Global CSP Installed

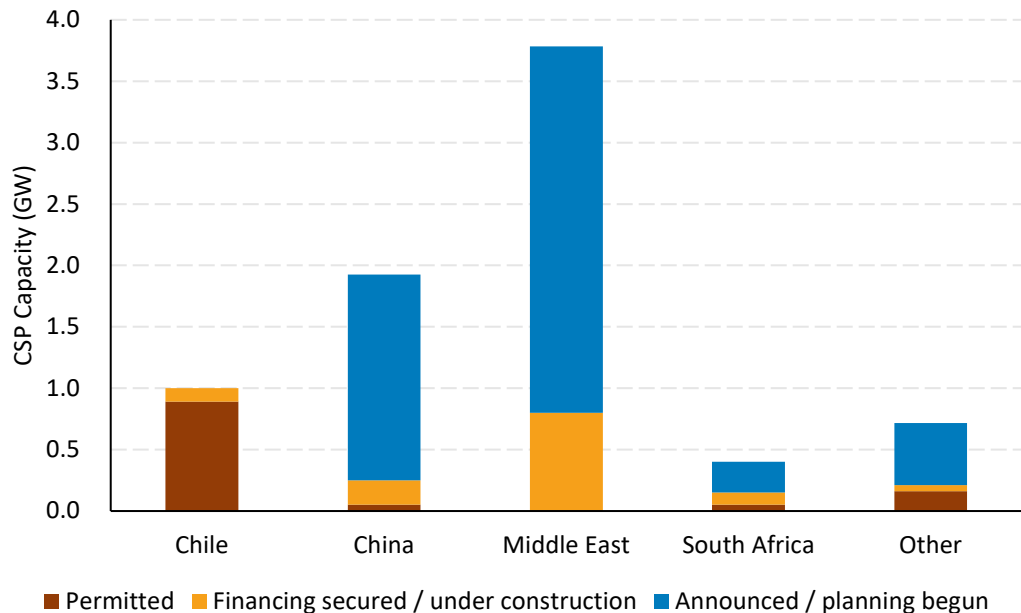
- In 2019, approximately 681 MW of CSP was installed globally in Israel, China, South Africa, and Kuwait.
  - Most of the projects were designed with storage of 4.5–13 hours.
  - China deployed a wide range of CSP technologies.

- From 2010 to 2019, global CSP installations increased by almost 6X.
  - Initially most of the growth came from Spain and the United States.
- From 2015–2019, approximately 2 GW of CSP was installed in other parts of the world, particularly the Middle East, North Africa, and China.
- There is also some development in other parts of the world, such as South America.

2019 CSP Installations (681 MW<sub>AC</sub>)



# Global CSP Pipeline



- In the near term, CSP projects are primarily expected to be built in Chile and the Middle East.
- In the longer term, significantly more projects are planned in China and the Middle East.

## 1 Global Solar Deployment

## 2 CSP Deployment

## 3 U.S. PV Deployment

## 4 PV System Pricing

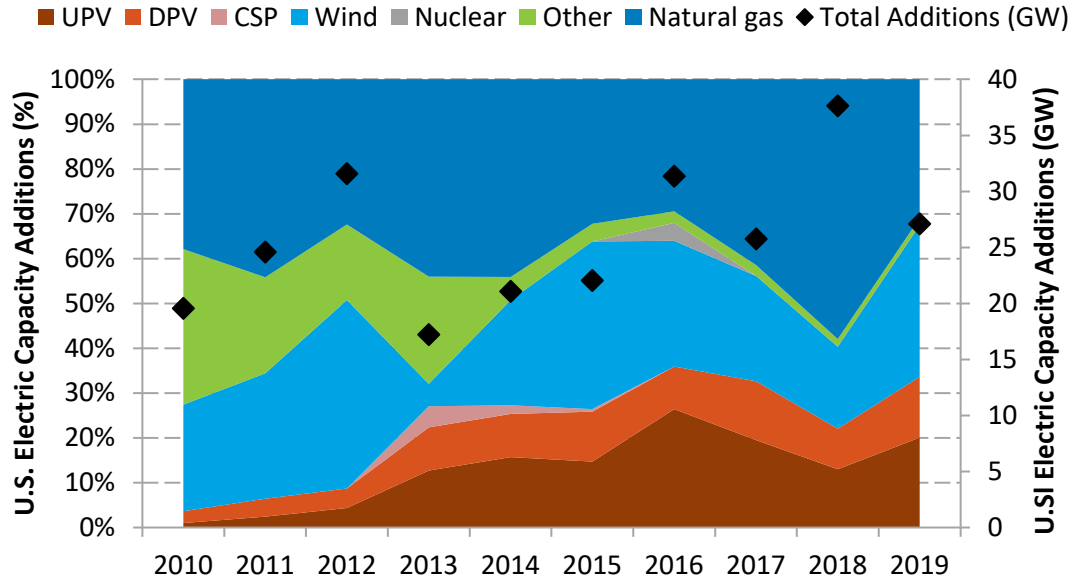
## 5 Global Manufacturing

## 6 Component Pricing

## Market Activity

- **The United States installed 13.4 GW<sub>DC</sub> of PV in 2019 and 5.9 GW<sub>DC</sub> in Q4, and cumulative capacity reached 76 GW.**
- **Since 2016, PV has represented approximately 30% of new U.S. electric generation capacity, with an estimated 34% in 2019.**
- **In 2019, solar represented 5.4% of net summer capacity and 2.6% of annual generation.**
  - **California has the highest penetration at almost 20% generation in 2019, representing a 52X increase from 2010 (0.4%).**
- **At the end of 2019, there were approximately 2.3 million residential PV systems in the United States.**
- **The United States installed approximately 1.1 GWh (0.5 GW) of energy storage onto the electric grid in 2019—up 43% y/y and 22X annual installations in 2013.**

# New U.S. Capacity Additions, 2010 -2019



- In 2010, PV represented approximately 4% of new U.S. electric generation capacity.
- Since 2016, PV has represented approximately 30% of new electric generation capacity, with an estimated 34% in 2019.
  - Combined with wind, two-thirds of all new capacity in 2019 came from renewable sources.

Note: "other" includes: coal; geothermal; landfill gas; biomass; petroleum.

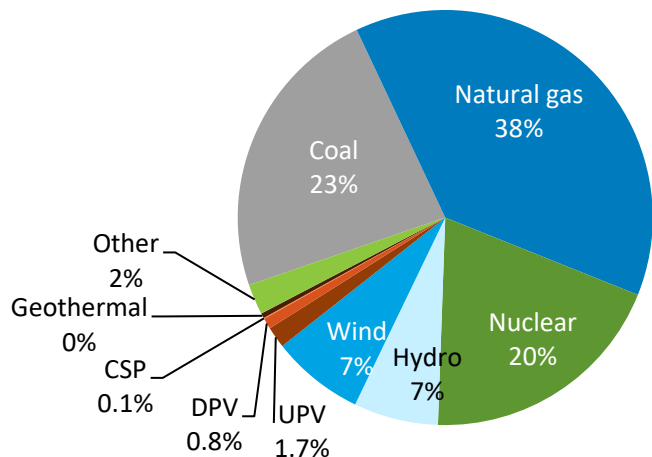
Sources: EIA, "Electric Power Monthly" Tables 6.1, 6.2B, 1.1, 1.1A; February 2020.

# 2019 U.S. Generation and Capacity

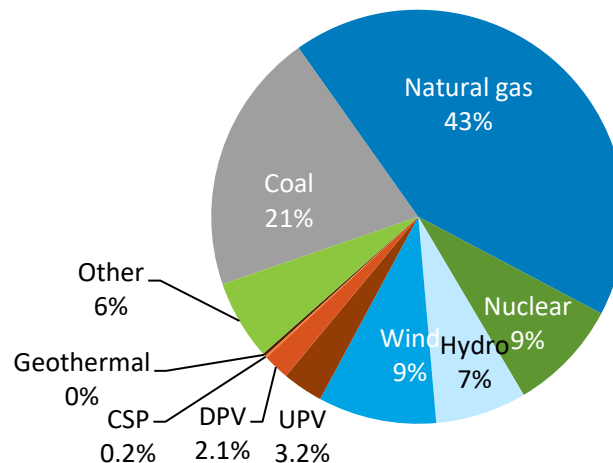
- Renewables are becoming an increasingly large part of the U.S. electric generation mix, representing 23% of capacity and 18% of generation in 2019.
  - Adding nuclear, non-carbon sources represented 32% of capacity and 38% of generation.

- Solar still represents a relatively small but growing percentage of the U.S. electric generation mix.
  - In 2019, solar represented 5.4% of net summer capacity and 2.6% of annual generation.
- Capacity is not proportional to generation, as certain technologies (e.g., natural gas) have lower capacity factors than others (e.g., nuclear).

2019 U.S. Generation (Total 4,153 TWh)

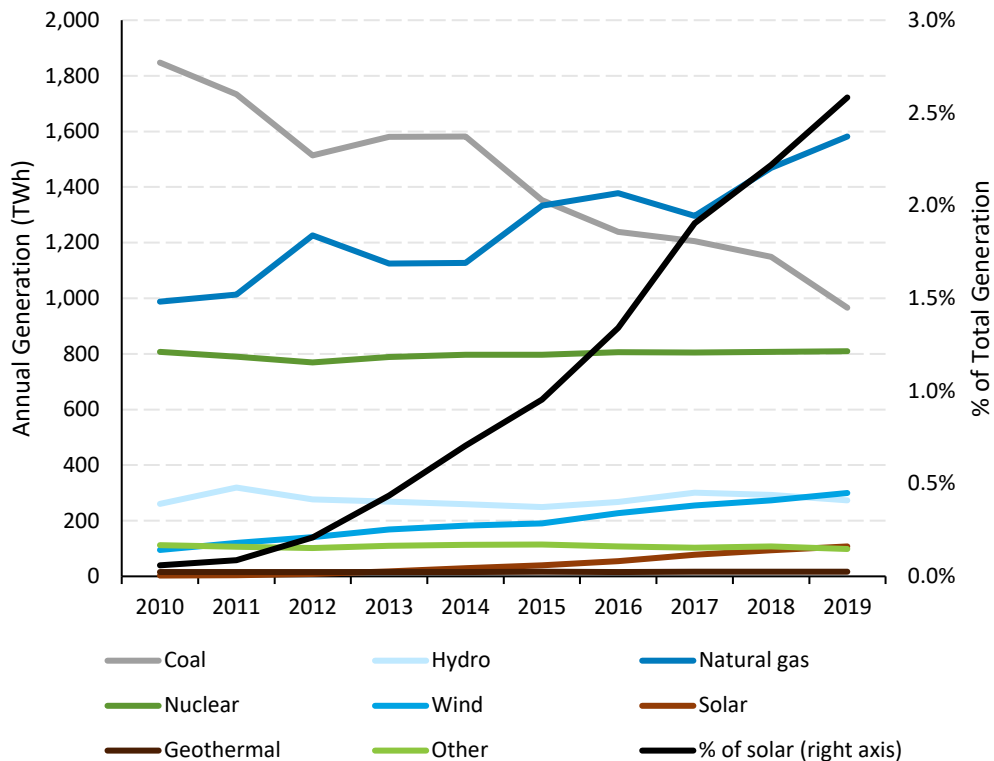


2019 U.S. Generation Capacity (Total 1.1 TW)



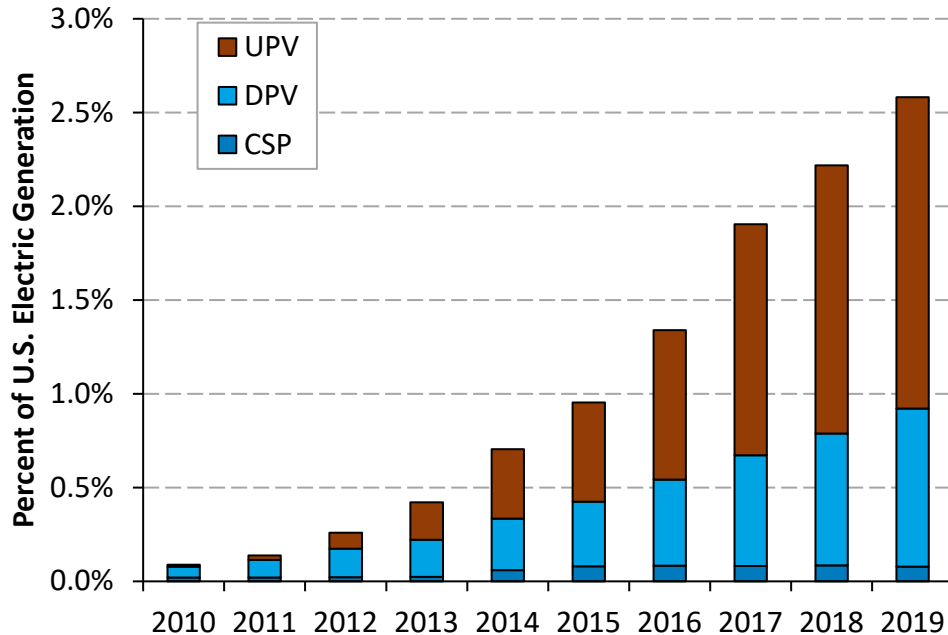


# U.S. Generation, 2010–2019



- Coal and natural gas generation have been heading in opposite directions during the past 10 years.
- The percentage of electricity generated by fossil fuels in the United States dropped from 70% in 2010 to 62% in 2019, while renewable generation increased from 10%–18% over the same time period.
- Despite solar only contributing 2.6% of electric generation in 2019, its percentage increased 43X since 2010.

# Solar Generation as a Percentage of Total Generation, 2010–2019

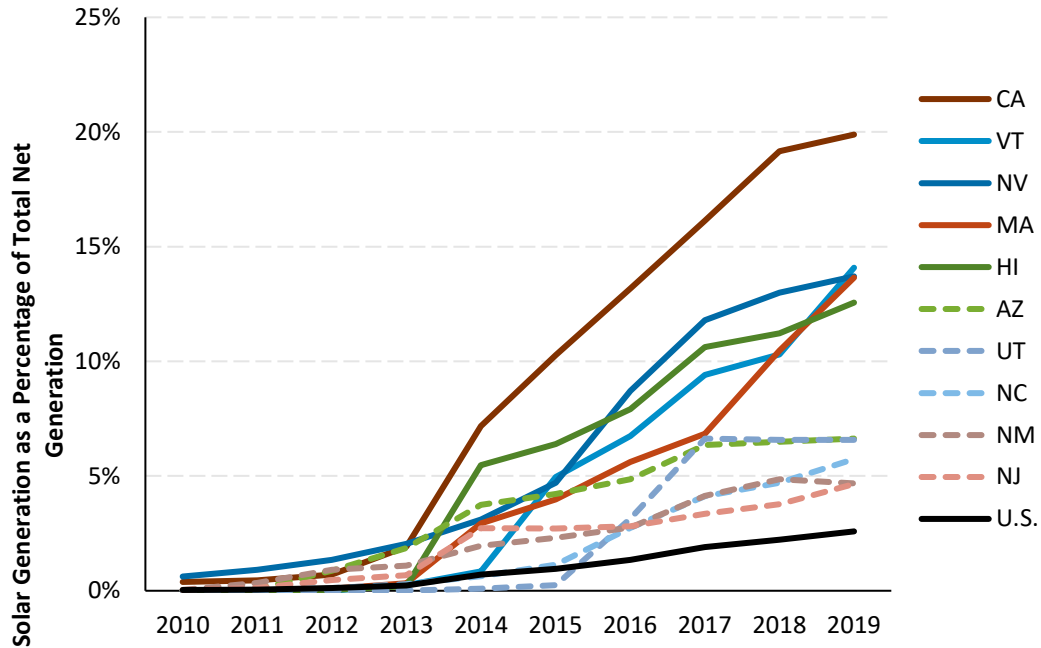


- In 2010, solar produced approximately 0.1% of total U.S. electric generation.
- By 2019, solar grew to 2.6% of electric generation.
  - 1.7% from utility-scale PV (UPV)
  - 0.8% from distributed PV (DPV)
  - 0.1% from concentrating solar power (CSP).

**Note:** EIA monthly data for 2018 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, “Electricity Data Browser.” Accessed May 24, 2020.

# Solar Generation as a Percentage of Total Generation of Total Generation, 2010–2019

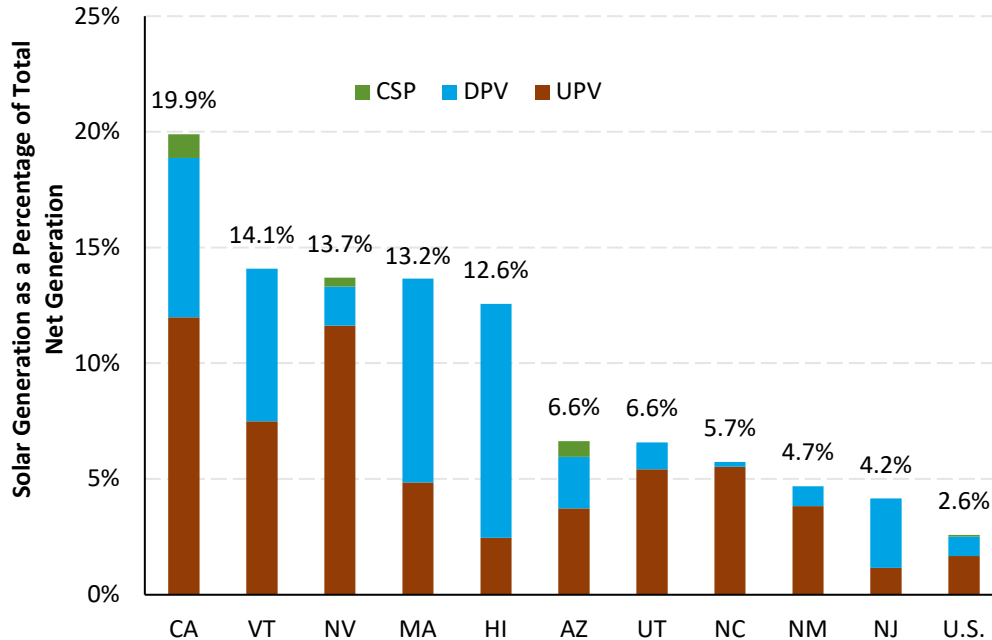


- The 10 states with the highest percentage of solar penetration generated at least 4.5% of their energy from solar in 2019.
  - California has the highest share with almost 20% in 2019, representing a 52X increase from 2010 (0.4%).
- In 2019, the United States produced approximately 2.6% of its electricity using solar technologies.
  - This represents an approximate 87X growth from 2010 (0.03%).

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# Solar Generation as a Percentage of Total Generation of Total Generation, 2019

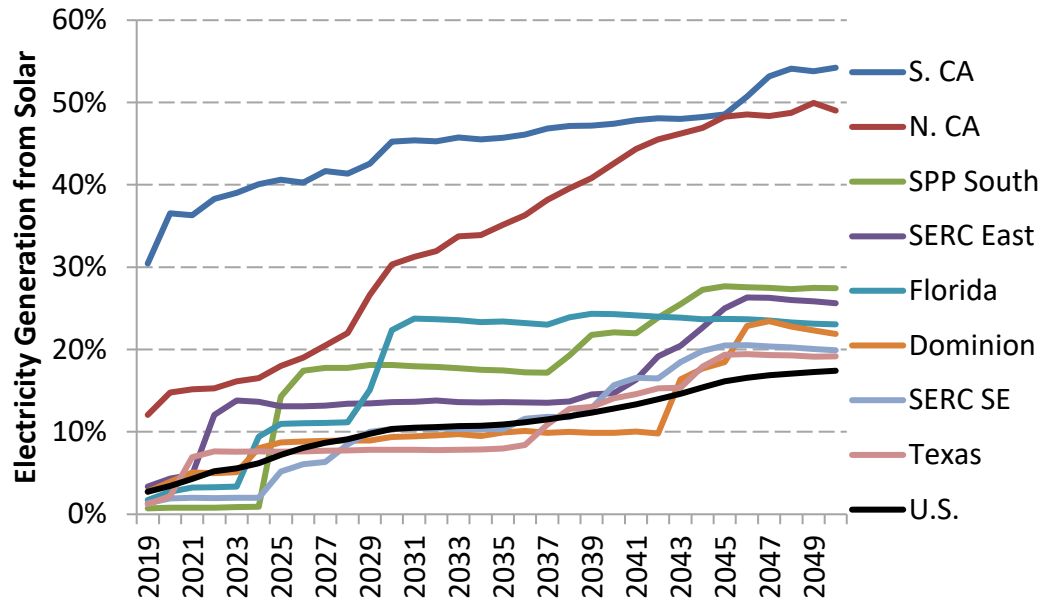


- The role of utility versus distributed solar varies by state.
  - DPV accounts for most of the solar market in MA, HI, and NJ.
  - UPV accounts for most of the solar market in NV, UT, NC, and NM.
  - There is a close-to-even split between the UPV and DPV market in CA, VT, and AZ.

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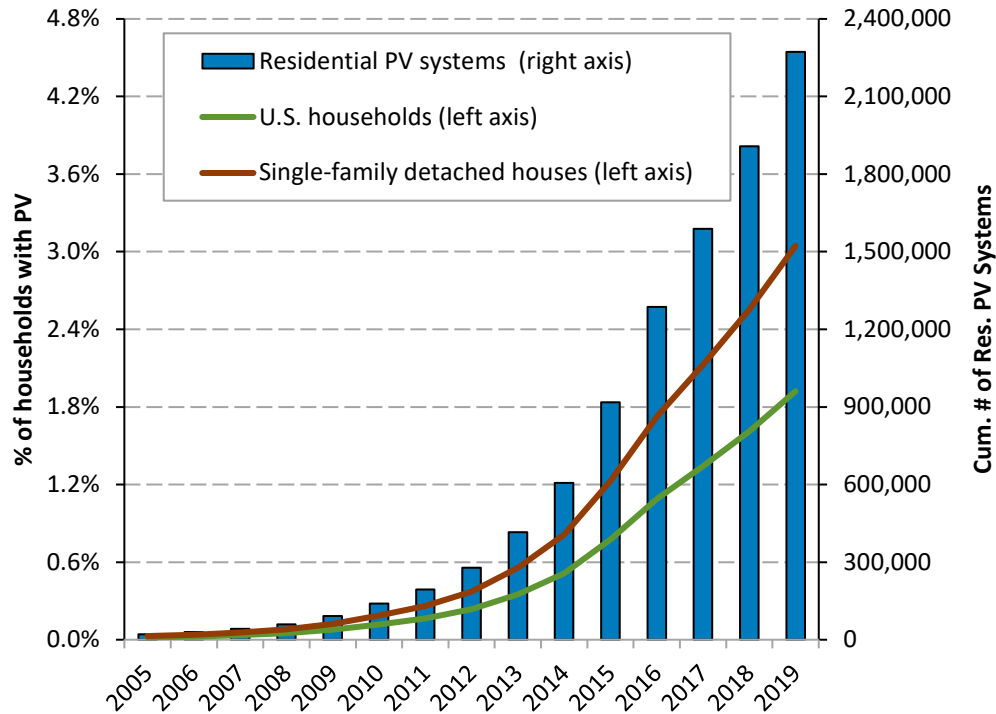
# EIA Projection of Future Electricity Generation from Solar



- EIA projects that electricity coming from solar will grow from 2.6% in 2019 to more than 17% by 2050.
- Some regions are expected to have higher levels of penetration, with California getting more than 50% of its generation from solar and some parts of the Southeast getting around 25%.

Source: EIA, "Annual Energy Outlook 2020."

# U.S. Residential PV Penetration



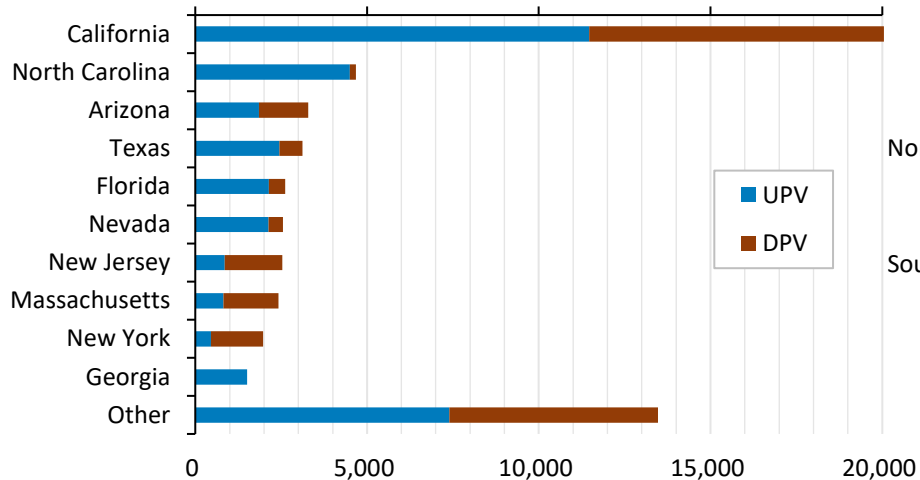
- Since 2005 when Congress passed the investment tax credit, the number of annually installed residential PV systems has grown by approximately 40% per year, or over 100X.
- At the end of 2019, there were approximately 2.3 million residential PV systems in the United States.
  - Still, only 1.9% of households own or lease a PV system (or about 3% of households living in single-family detached structures).
  - However, solar penetration varies by location. Hawaii, California, and Arizona have residential systems on an estimated 34%, 15%, and 12% of households living in single-family detached structures.

Sources: Res. PV Installations: 2000-2009, IREC 2010 Solar Market Trends Report; 2010-2019, SEIA/Wood Mackenzie [Solar Market Insight 2019 Year-in-Review](#); U.S. Households U.S. Census Bureau, 2015 American Housing Survey; state percentages based on 2000 survey; Hawaii, California, and Arizona solar data from EIA form 861M.

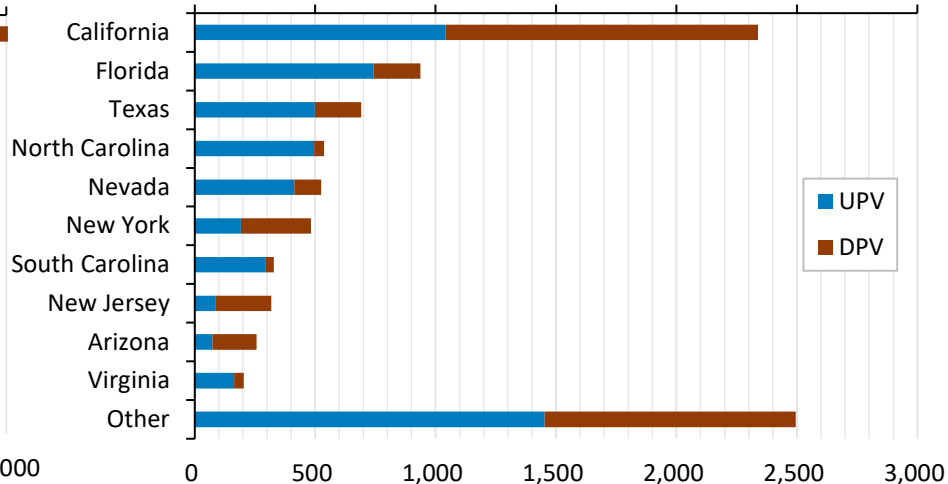
# U.S. Installation Breakdown by State

- At the end of 2019, there were 58.8 GWAC of solar systems in the United States; 35.6 GW of which were utility-scale PV and 23.2 GW were distributed PV.
- In 2019, approximately 9.1 GWAC of PV capacity was installed; 5.4 GW of which were utility-scale PV and 3.7 GW were distributed PV.

**Cumulative Installed Capacity, Top 10 States, 2019**  
Megawatts (MW-AC)



**Installed Capacity, Top 10 States, 2019**  
Megawatts (MW-AC)

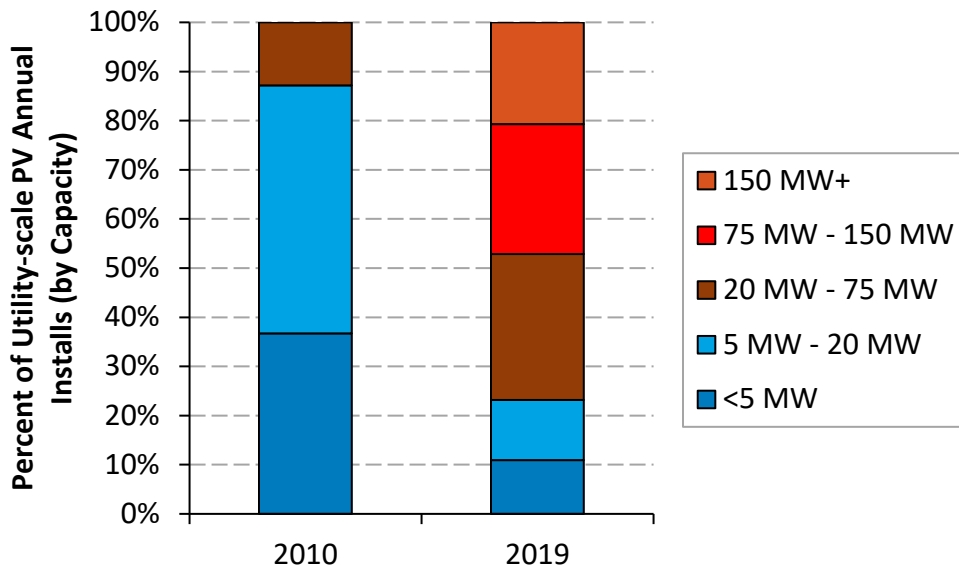


**Note:** EIA monthly data for 2019 are not final. Additionally, smaller utilities report information to EIA on a yearly basis, and therefore, a certain amount of solar data has not yet been reported. "Net Generation" includes DPV generation.

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

# Average System Size

## Size of Utility-scale PV Installations by Year



- From 2010 to 2019, average system installation size grew from:
  - 5.0 kW<sub>DC</sub> to 7.7 kW<sub>DC</sub> for residential
  - 70 kW<sub>DC</sub> to 212 kW<sub>DC</sub> for non-residential
  - 5 MW<sub>DC</sub> to 27 MW<sub>DC</sub> for utility-scale.
- The number of smaller utility-scale PV systems hides some of the shift in focus to very large utility-scale plants.
  - In 2010, only 13% of PV systems built were above 20 MW<sub>AC</sub>, with the largest system 30 MW<sub>AC</sub>. In 2019, however, two-thirds of the utility-scale capacity installed came from systems above 20 MW<sub>AC</sub>, with the largest system at 250 MW<sub>AC</sub>.

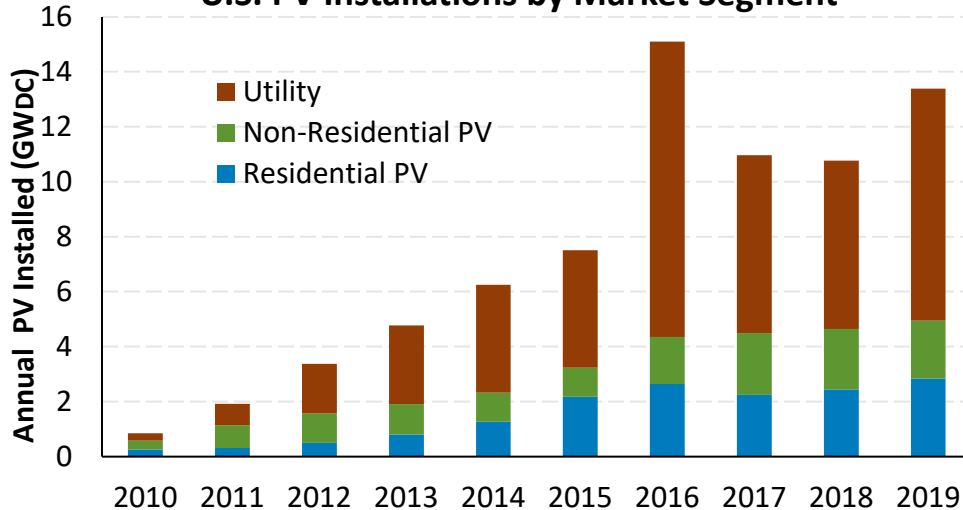


# U.S. Installation Breakdown Annual

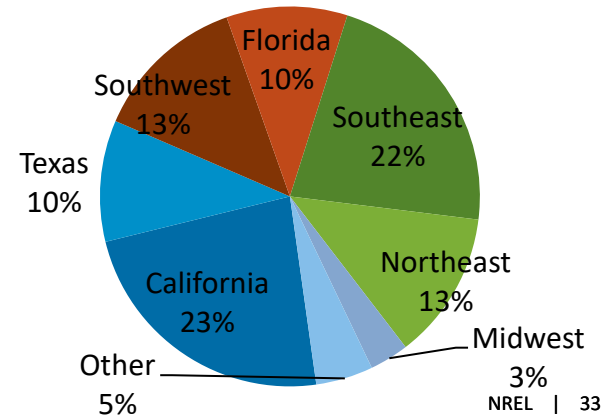
- The United States installed 13.4 GWDC of PV in 2019 and 5.9 GWDC in Q4, and cumulative capacity reached 76.0 GW.
  - 2019 U.S. PV installations were up 24% y/y with the residential and utility-scale markets growing 16% and 38%, respectively, but the non-residential markets contracting 4%.

- In 2019, new PV installations have had a fair geographic mix across the United States, though most capacity was installed in southern states.
  - The U.S. solar market is becoming less dependent on California, as California's 2019 market share was the lowest on record.
  - States with nascent markets five years ago are now driving significant demand. In 2015, Texas and Florida totaled 4% of new U.S. PV installations and in 2019 represented 20%.

## U.S. PV Installations by Market Segment



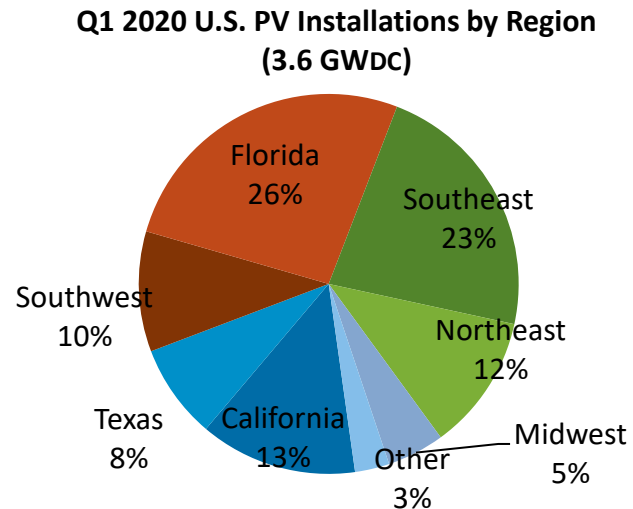
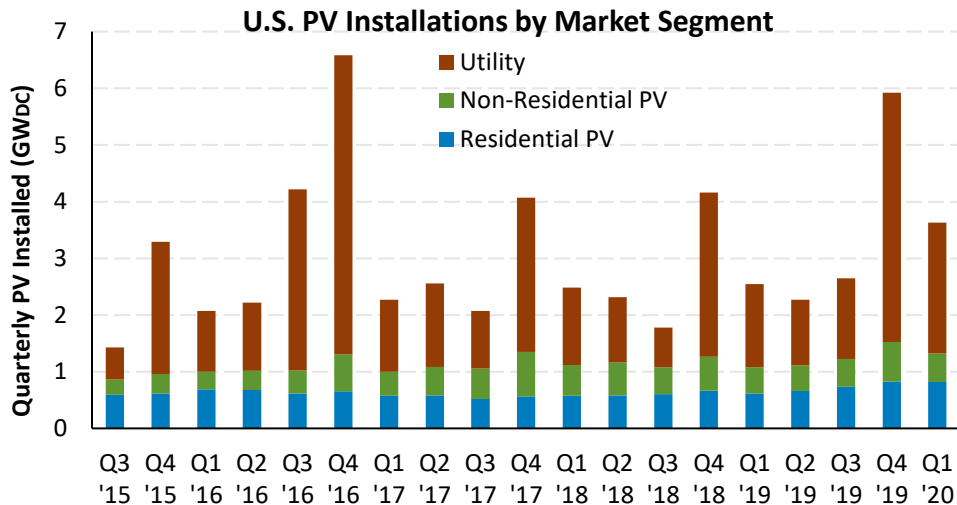
## 2019 U.S. PV Installations by Region (13.4 GWDC)



# U.S. Installation Breakdown Quarterly

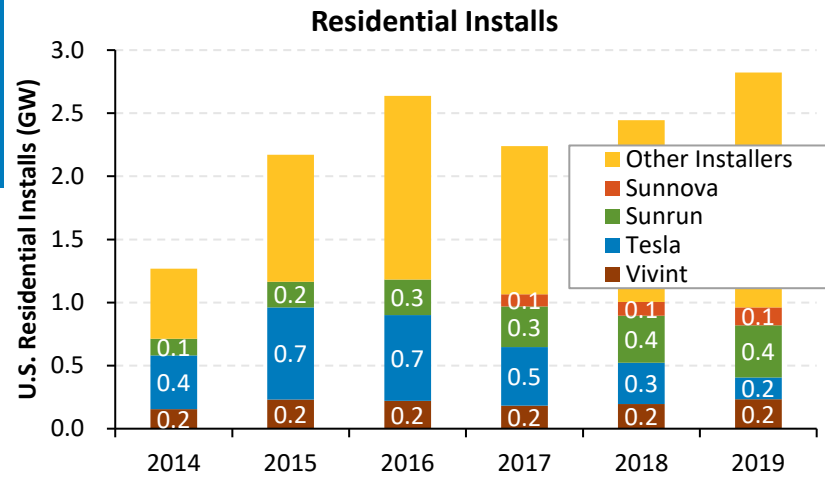
- Despite possible effects of COVID-19, the United States installed 3.6 GWdc of PV in Q1 2020, its largest Q1 total ever—up 43% y/y.
  - Residential PV installations had their second highest-quarter ever, with 25 states adding more than 500 installations.

- Approximately 50% of U.S. PV capacity installed in Q1 2020 occurred in the Southeast, with Florida accounting for 26% of the total market.
- The only other time on record that California's quarterly market share was in the teens was 17% in Q4 2010.

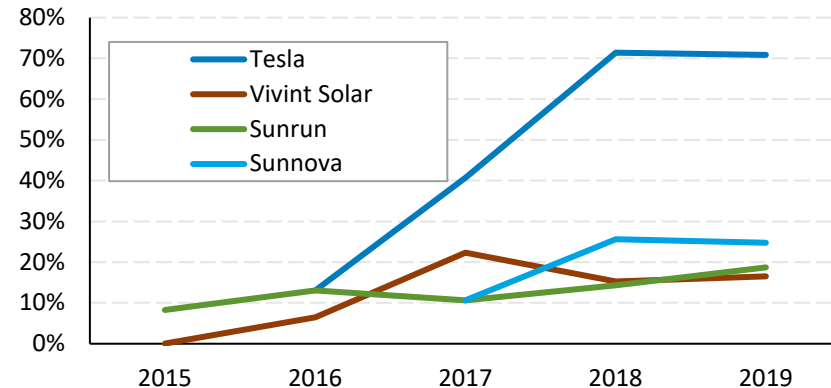


# Tesla, Vivint Solar, Sunrun, and Sunnova Residential Market Share

- In 2019, U.S. residential installations increased 15% y/y; excluding these four installers, residential installations increased 31%.
  - Many national integrators' sales grew in 2019, however Tesla installed 47% fewer MWs y/y.
- While direct sales and loans represent a sizable part of national integrators' sales, the bulk of their installations are through leases and PPAs.
  - Tesla, which had pivoted to cash sales in 2016, recently announced plans to switch back to leases via its "subscription service."

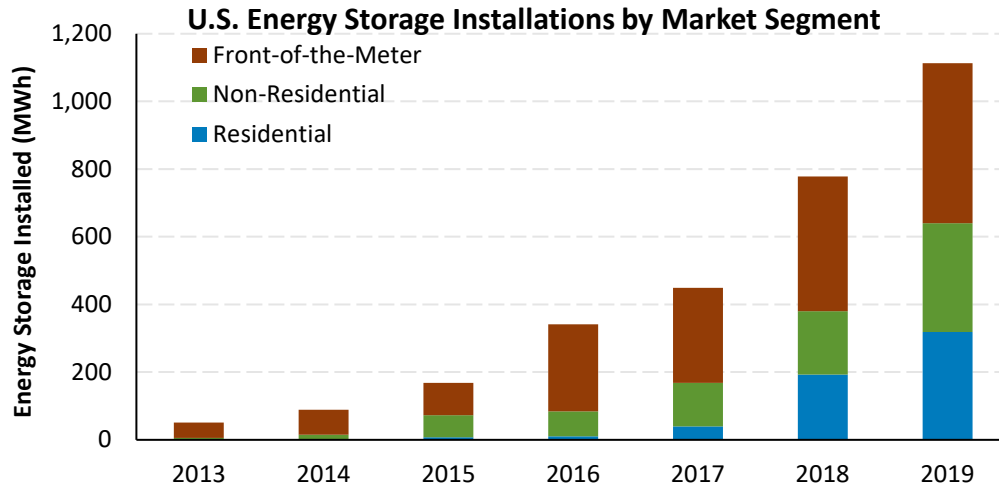


## Percent of Direct Sales / Loans



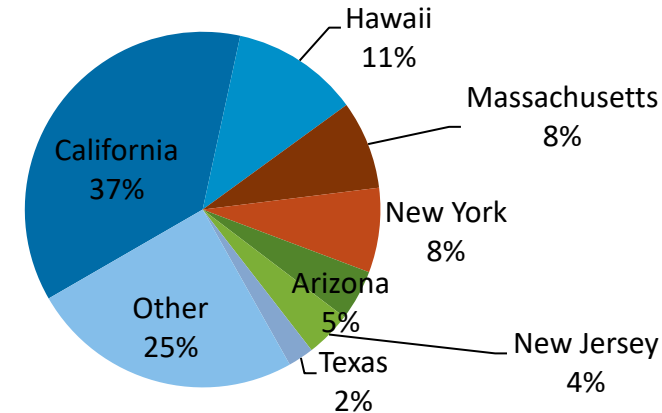
# U.S. Energy Storage Installations by Market Segment

- The United States installed approximately 1.1 GWh (0.5 GW) of energy storage onto the electric grid in 2019—up 43% y/y and 22X annual installations in 2013.
- Integrated resource planning (IRP) created significant demand for front-of-the-meter storage, with 9 GW of storage outlined in utilities' IRP to come online by 2030.

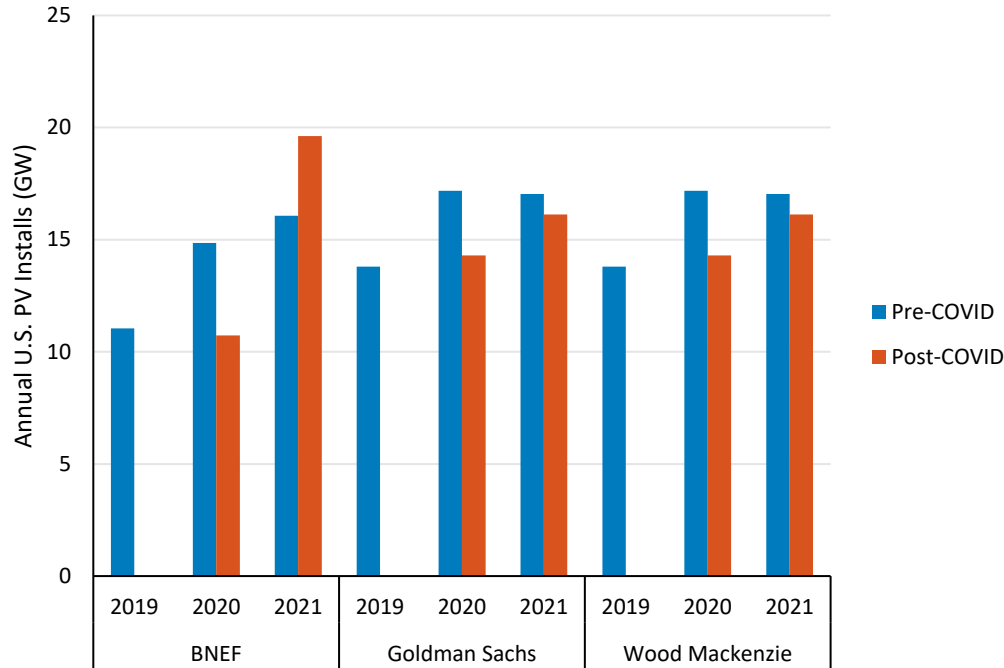


- In 2019, California wildfires spurred interested in PV+storage.
- Some solar installers in Hawaii report that 100% of their pipeline is paired with storage. Hawaii also has a robust utility-scale PV+storage slate of projects.
- The non-residential market had a record-breaking year in 2019, but its pipeline significantly shrunk, and many companies have exited the industry or shifted to FTM systems.

## U.S. Energy Storage Installations by Region (1.1 GWh)



# Change in U.S. Projections from COVID-19



- Before the spread of COVID-19, analysts had projected that U.S. PV demand would grow 25%–34% from 2019 to 2020.
- More recently, analysts have revised their projections for U.S. PV demand in 2020 to be relatively flat.
- Most analysts still expect U.S. demand to rebound in 2021 to approximately the same levels as they had previously predicted, i.e., significantly above 2019 installations.

# Revised 2020 EIA U.S. Projections Due to COVID-19

Power Source	MWAC Affected	Share of Delays
Solar	1,673	34%
Wind	1,638	33%
Natural Gas	1,550	31%
Other	87	2%

- EIA’s most recent Short-Term Energy Outlook reported that:
  - 4.9 GWAC of utility-scale capacity that was expected to come online between April and September 2020 (or 39%) will be either “canceled or indefinitely postponed.”
  - Solar PV is expected to be the hardest hit with 34% delayed. This level of delay would reduce projected 2020 PV installations by about 10% to 12.6 GWAC.
  - 12.6 GWAC in 2020 would still represent a 30% increase over what was installed in 2019.
  - Beyond 2020, EIA expects the PV market to continue to grow, projecting 12.9 GWAC will be installed in 2021.



1 Global Solar Deployment

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2 CSP Deployment

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3 U.S. PV Deployment

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4 **PV System Pricing**

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5 Global Manufacturing

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6 Component Pricing

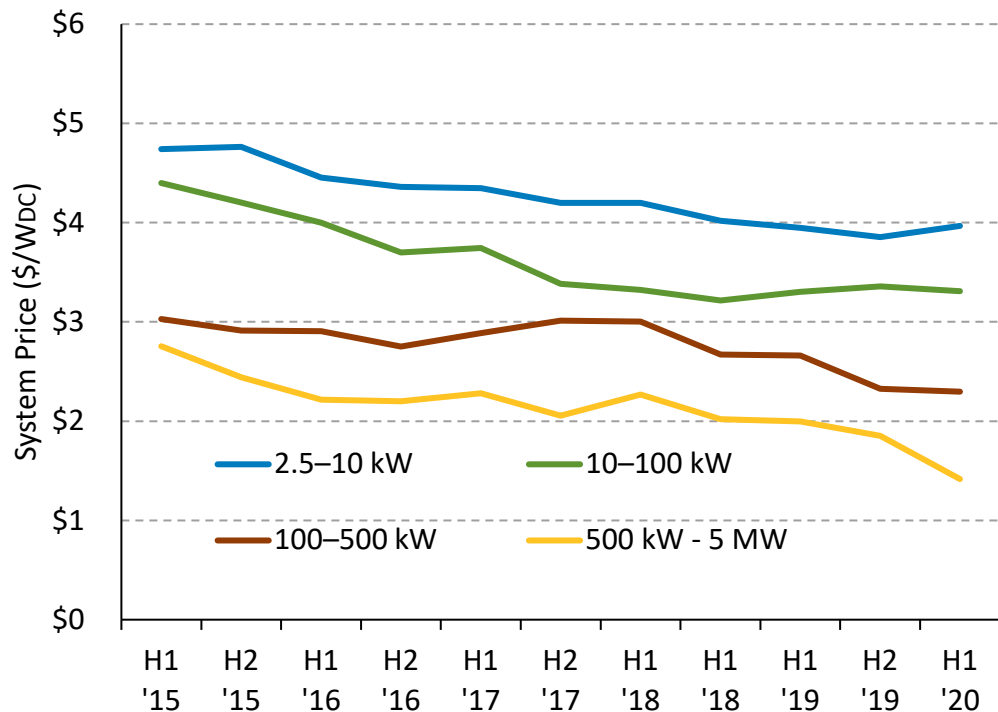
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Market Activity

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- From H2 2018 to H2 2019, EnergySage reported a 4% reduction in the median gross costs of a residential PV system to \$2.89/W<sub>DC</sub>.
- Despite PV installation cost declines, total system costs and prices for national solar integrators have remained relatively flat or risen due to increased SG&A.
- In a select data set of utility-scale PV systems (109 projects totaling 3.3 GW<sub>AC</sub>) owned by 20 regulated utilities, the median system price in 2019 was \$1.34/W<sub>AC</sub> ( \$0.89/W<sub>DC</sub>)—relatively flat y/y.

# System Pricing from Select States



**2019 MW:** AZ (66), CA (277), CT (9), MA (77), NY (362)

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

**Sources:** AZ (05/24/20), CA NEM database (03/31/20); CT (02/01/20), MA SREC and SMART programs (03/09/20); NYSERDA (05/24/20).

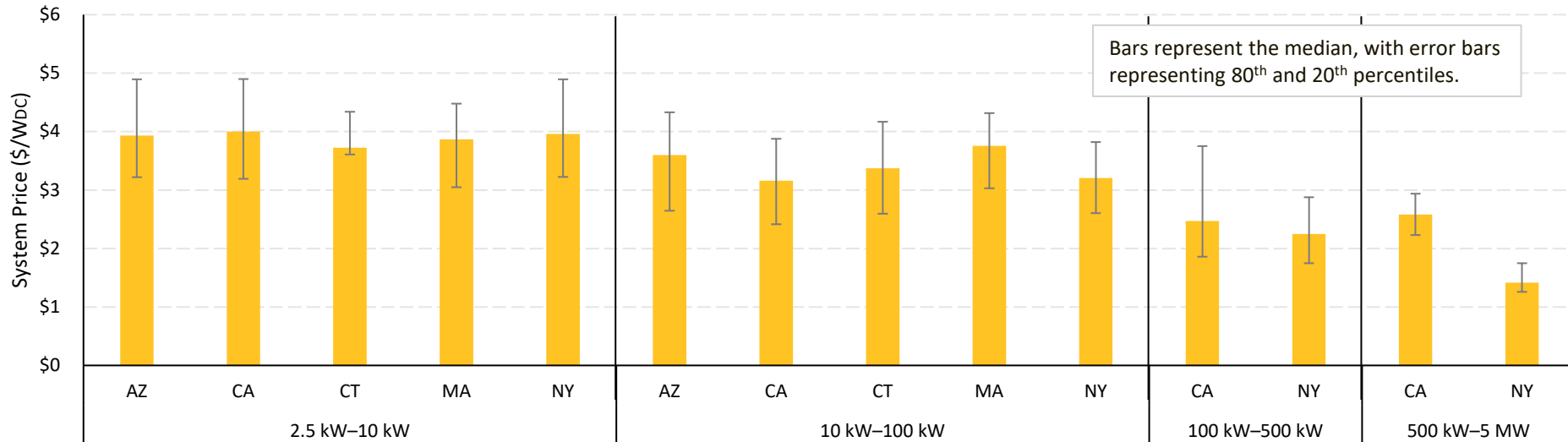
- From 2018 to 2019, the median reported PV system price in Arizona, California, Connecticut Massachusetts, and New York:
  - Fell 5% to \$3.89/W for systems from 2.5 kW to 10 kW
  - Increased 2% to \$3.33/W for systems from 10 kW to 100 kW
  - Fell 17% to \$2.44/W for systems from 100 kW to 500 kW
  - Fell 11% to \$1.96/W for systems from 500 kW to 5 MW.
- Based on preliminary Q1 2020 data, the median reported PV system price in Arizona, California, Connecticut, Massachusetts, and New York remained relatively flat with the exception of systems above 500 kW, which dipped to \$1.4/W.



# System Pricing from Select States, Q1 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 systems in New York was about 45% less than the median price in California.
- In Q1 2020, the 20<sup>th</sup> and 80<sup>th</sup> percentile preliminary prices in California for a small system were \$3.19/W and \$4.90/W, respectively.



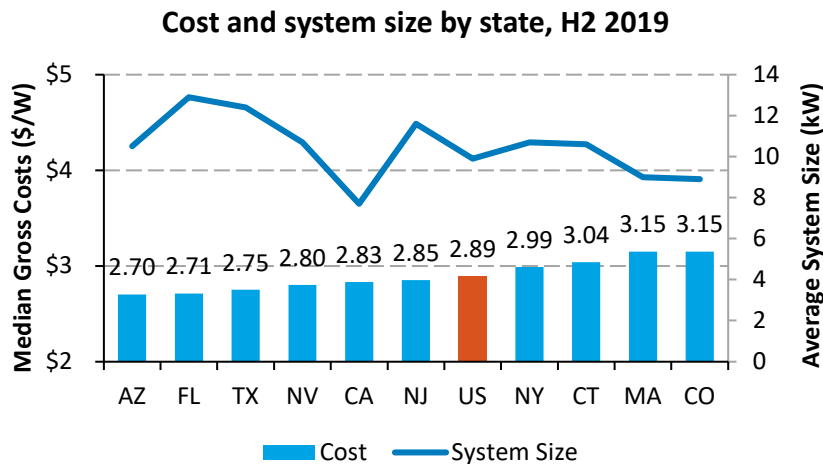
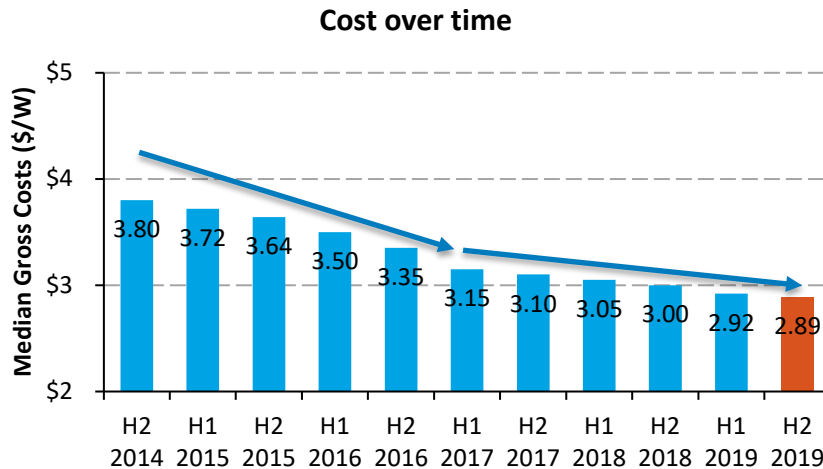
**Q1 2020 MW:** AZ (7), CA (67), CT (0.1), MA (15), NY (131)

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

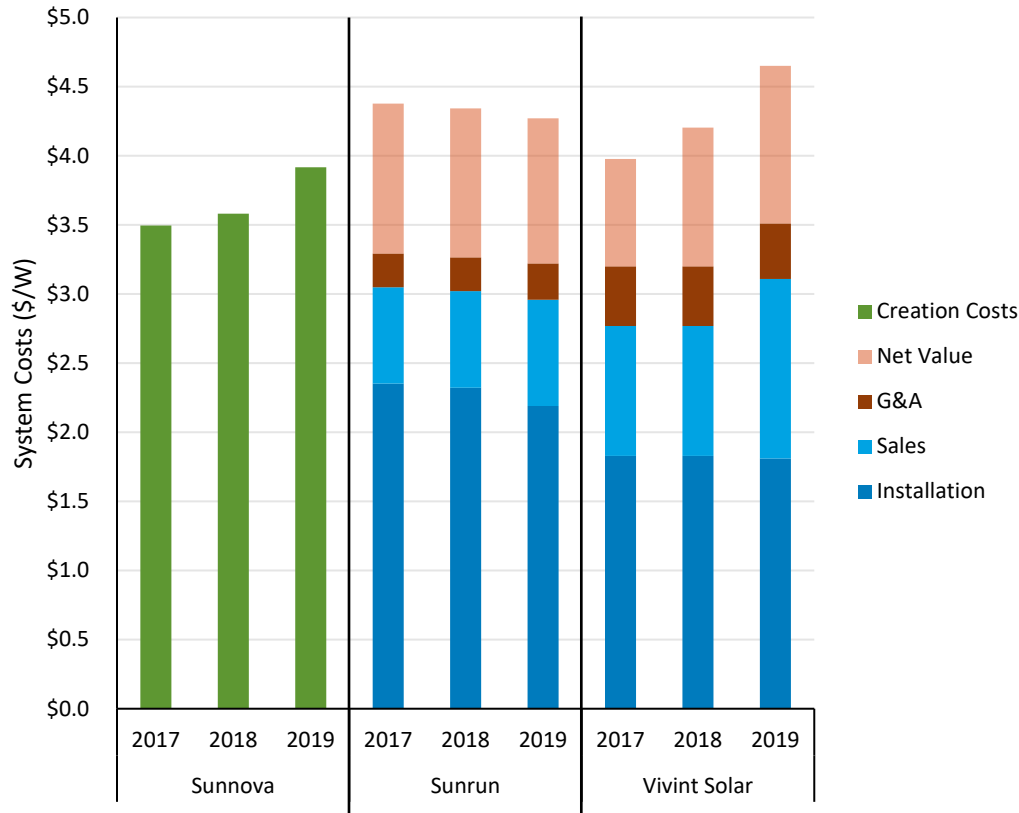
**Sources:** AZ (05/24/20), CA NEM database (03/31/20); CT (02/01/20), MA SREC and SMART programs (03/09/20); NYSERDA (05/24/20).

# Residential System Costs Reported by EnergySage, H2 2019

- Since H1 2017, median gross cost declines of residential systems in EnergySage’s dataset have slowed.
  - From H2 2014 to H1 2017, EnergySage reported annual price declines of 7%; however, from H1 2017 to H2 2019, annual price declines were 3% on average.
- From H2 2018 to H2 2019, EnergySage reported a 4% reduction in the median gross costs of a residential system.
- Residential system quotes varied by state. In H2 2019, the median gross cost of a residential system in Colorado was 17% 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, with many of the larger, lower-cost systems in states with high electricity consumption due to air conditioning (e.g. Arizona, Florida, Texas, and Nevada).

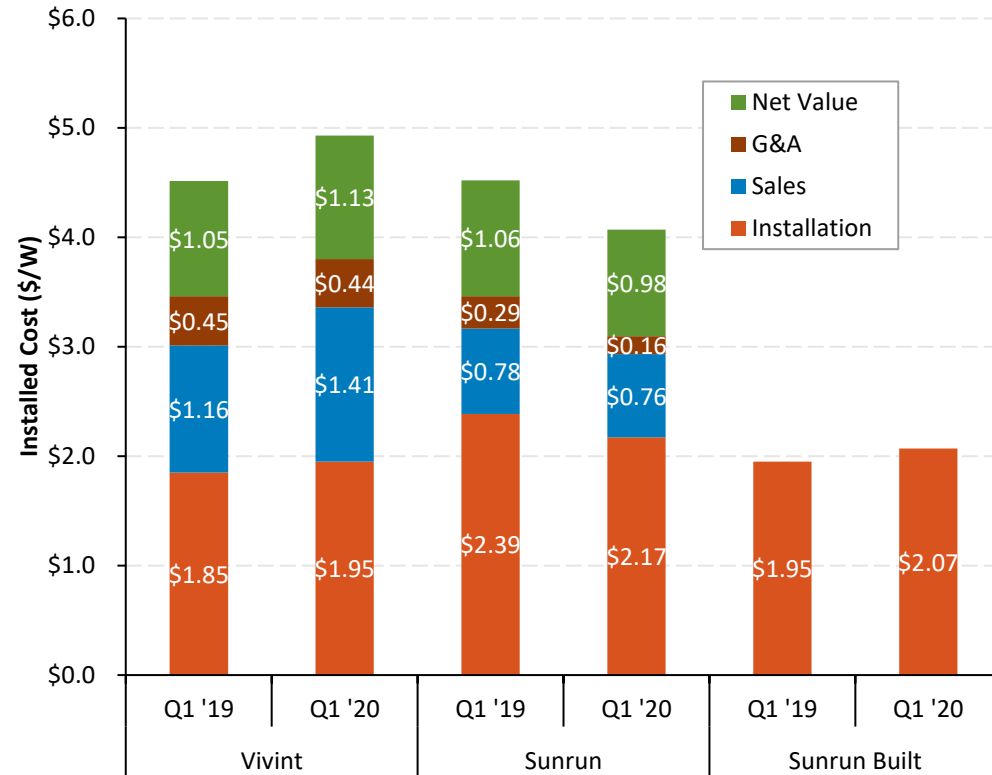


# Sunnova, Sunrun, and Vivint Cost and Value, 2017-2019



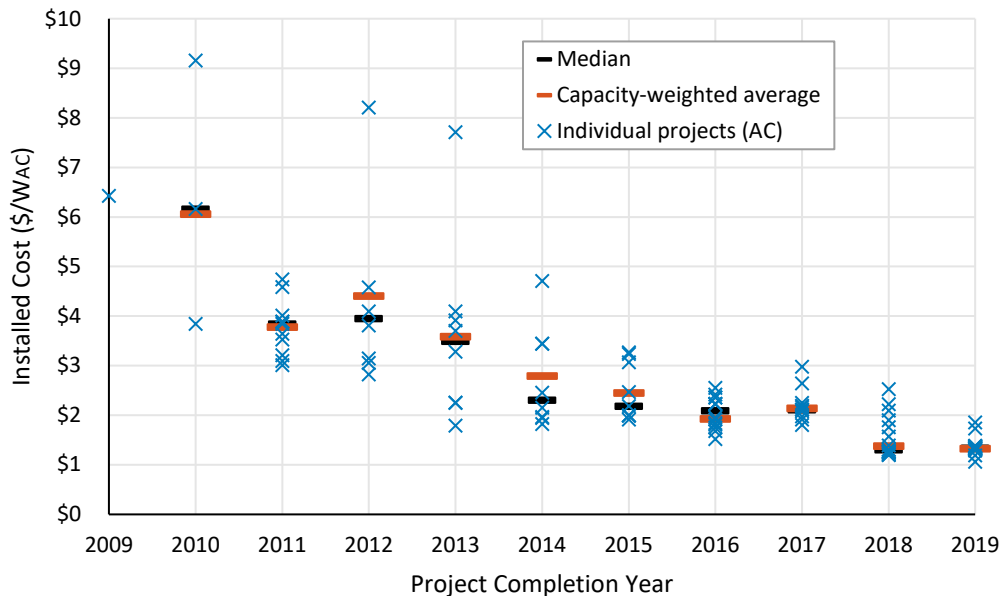
- Despite installation cost declines, total system costs and price for national solar integrators have remained relatively flat or risen due to increased SG&A.

# Sunrun and Vivint Solar Cost and Value, Q1 2020



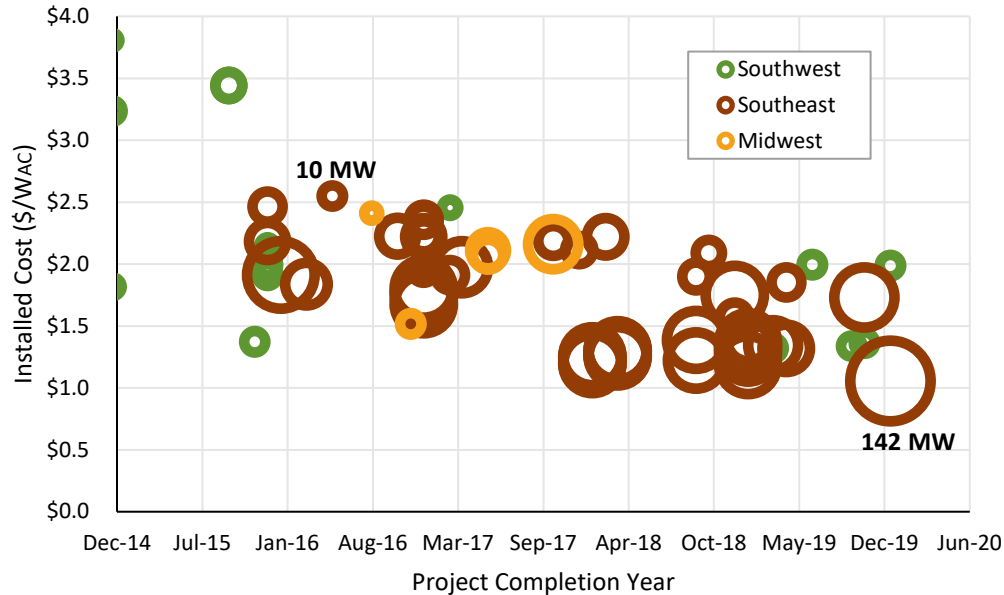
- In Q1 2020, Sunrun and Vivint Solar’s system costs (including installation, sales, and G&A) were \$3/W–\$4/W, and net values were \$4/W–\$5/W.
- Vivint Solar’s costs increased y/y due to increasing installation and customer acquisition costs, while Sunrun’s costs decreased with lower installation and general and administrative costs.
  - Part of the reduction in Sunrun’s costs could be attributed to building more systems themselves, which costs less. However, like Vivint Solar, Sunrun estimates installation costs to have increased y/y for systems they installed themselves.

# Utility-Owned PV Pricing (>5 MW)



- In a select data set of utility-scale PV systems (109 projects totaling 3.3 GW<sub>AC</sub>) owned by 20 regulated utilities, the median system price in 2019 was \$1.34/W<sub>AC</sub>—relatively flat y/y.
  - The 2019 median price in this dataset was \$0.89/W<sub>DC</sub>. The high median inverter loading ratio comes from several fixed-tilt Florida projects with ILR values of 1.5.
  - The lowest and highest reported prices in 2019 were \$1.06/W<sub>AC</sub> and \$1.85/W<sub>AC</sub> (or \$0.78/W<sub>DC</sub> and \$1.41/W<sub>DC</sub>).
  - From 2010 through 2019, system prices in this data set fell 16% per year on average.

# Utility-Owned PV Pricing (>5 MW)



- In a select data set of utility-scale PV systems (107 projects totaling 3.3 GWAC) owned by 20 regulated utilities, the average system size has trended upward as system pricing has trended downward.
  - The average system size in this dataset was 14 MWAC in 2015 and 51 MWAC in 2019.
- System prices in this dataset may be lower than the national average as they do not include data from higher cost regions, such as California and the Northeast—areas with far less utility ownership of PV systems.

## 1 Global Solar Deployment

## 2 CSP Deployment

## 3 U.S. PV Deployment

## 4 PV System Pricing

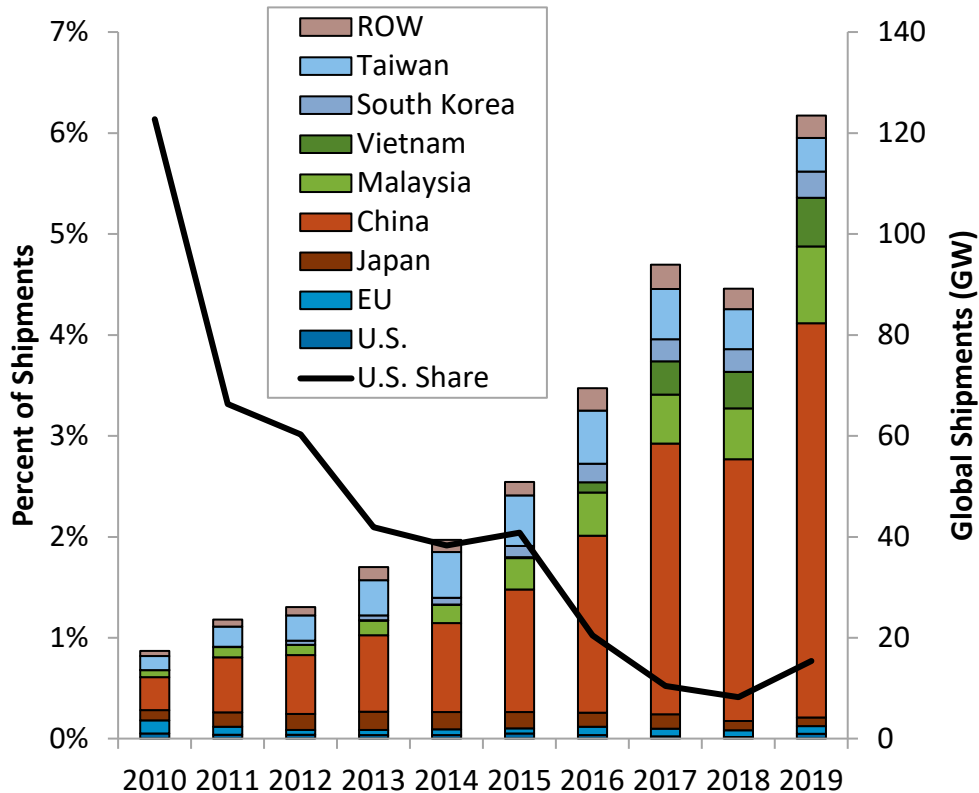
## 5 Global Manufacturing

## 6 Component Pricing

## Market Activity

- In 2019, global PV shipments were approximately 123 GW—an increase of 39% from 2018.
- In 2019, 62% of PV shipments were mono c-Si technology—a level not seen since the early 1980s.
- In 2019, revenue from PV deployment was more than 10X revenue from PV manufacturing.
- Despite tariffs, PV modules and cells are being imported at historically high levels.
  - 7.1 GW of PV modules were imported in the Q1 2020.
  - Another 0.8 GW of cells were imported in Q1 2020.
- From 2010 to 2019 efficiency gains for modules installed in the United States were:
  - 14.4% to 19.4% for mono c-Si
  - 13.7% to 17.4% for multi c-Si
  - 11.0% to 17.4% for CdTe.

# Global Annual PV Shipments by Region\*



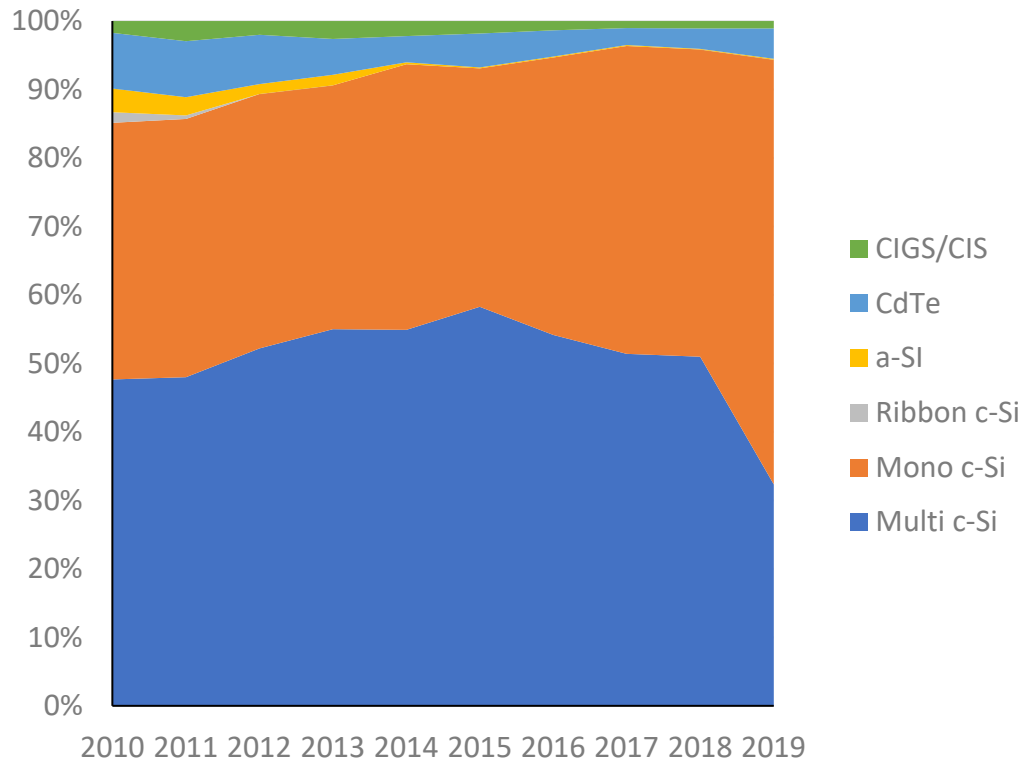
\*Note: Excludes inventory sales and outsourcing.

Source: 2010-2019: Paula Mints. "Photovoltaic Manufacturer Capacity, Shipments, Price & Revenues 2019/2020." SPV Market Research. Report SPV-Supply8. April 2020.

- In 2019, global PV shipments were approximately 123 GW—an increase of 39% from 2018.
- Since 2010, the U.S. share of global PV shipments declined from around 6% to less than 1%.
- Over the same time period:
  - China's share of global PV shipments grew from 37% to 63%.
  - Together the share of Malaysia, Vietnam, and South Korea went from 8% to 24% (with Vietnamese growth coming on rapidly during the last four years).



# Global Annual PV Shipments by Technology\*

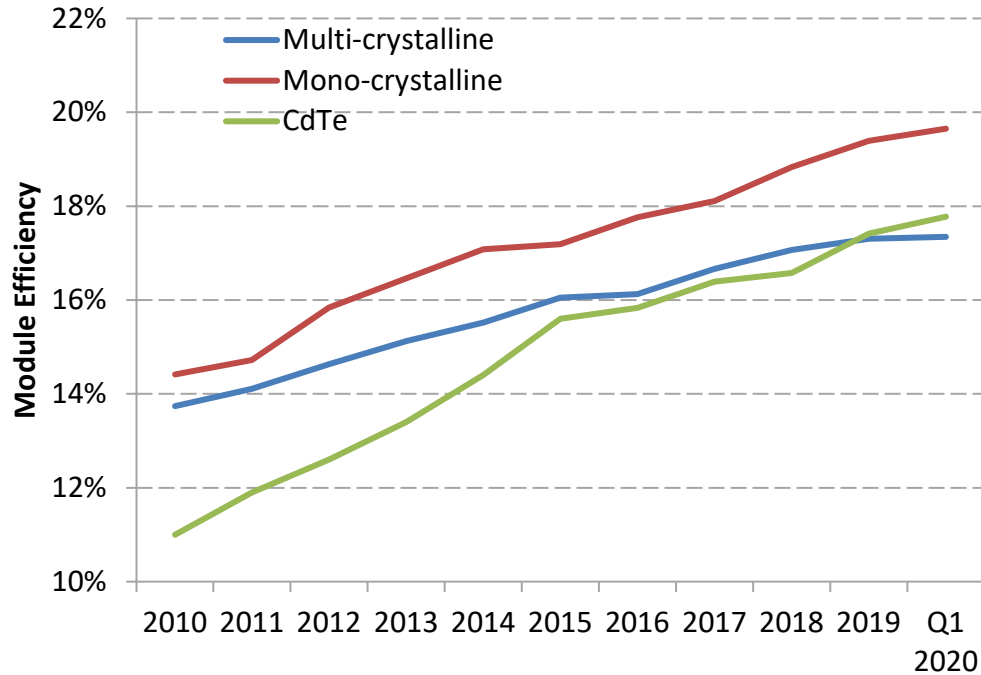


- In 2019, 62% of PV shipments were mono c-Si technology—a level not seen since the early 80s.
- Multi c-Si peaked five years ago in 2015 at 58% of global shipments.
- Most analysts expect mono c-Si to continue gaining market share in the next 5-10 years.

\*Note: Excludes inventory sales and outsourcing.

Sources: 2010-2019: Paula Mints. "Photovoltaic Manufacturer Capacity, Shipments, Price & Revenues 2019/2020." SPV Market Research. Report SPV-Supply8. April 2020. ITRPV Roadmap 2019.

# PV Efficiency Improvements



- From 2010 to 2019, the efficiency of modules installed in the United States increased significantly:
  - 14.4% to 19.4% for mono c-Si
  - 13.7% to 17.4% for multi c-Si
  - 11.0% to 17.4% for CdTe.
- Based on preliminary data for Q1 2020, the average efficiency of mono c-Si and CdTe panels installed in the United States have continued to increase, while multi c-Si has begun to lag behind.

# Global Leading PV Manufacturers, by Shipments

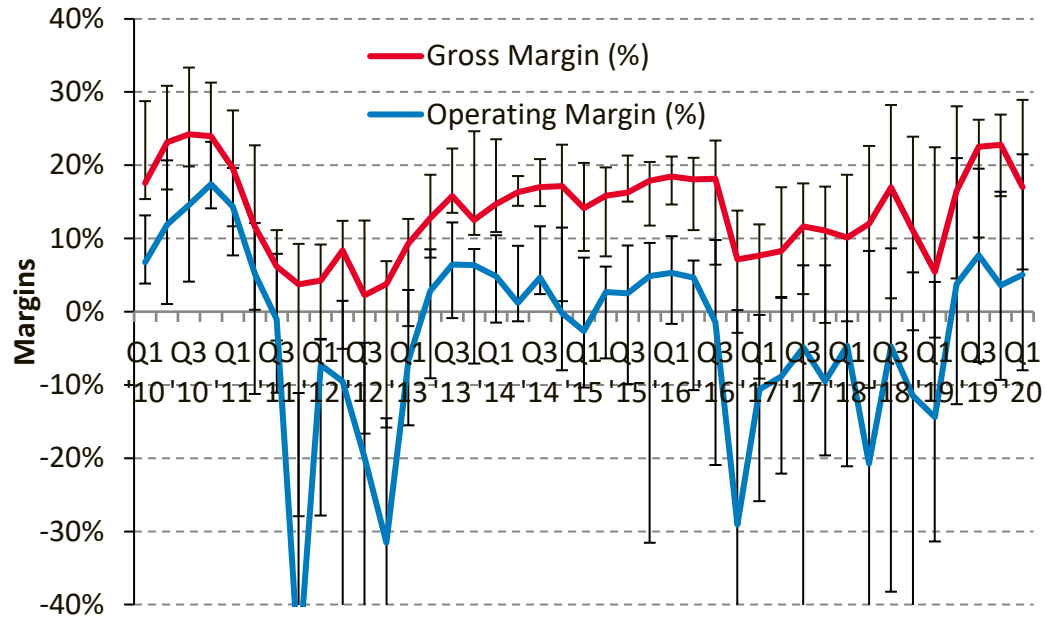
Ranking	2010	2010 MWp	2015	2015 MWp	2019	2019 MWp
1	Suntech	1572	Trina	3631	Tongwei	12752
2	JA Solar	1460	JA Solar	3617	LONGi	10957
3	First Solar	1387	Hanwha Q-Cells	3400	Jinko Solar	9708
4	Yingli	1062	Canadian Solar	2691	Canadian Solar	8600
5	Q-Cells	995	First Solar	2518	Aiko Solar	7610
6	Sharp	914	Jinko Solar	2400	JA Solar	7560
7	Trina	905	Yingli	2388	Trina Solar	6006
8	Motech	850	Motech	2100	First Solar	5400
9	Gintech	800	NeoSolar	2100	Hanwha Q-Cells	5185
10	Kyocera	631	Shungfeng-Suntech	1970	UREC	4219
Total Above		10576		26815		77997
Total Ship. MWp		17402		50877		123485

- From 2010 to 2019, shipments from the top 10 PV manufacturers grew from 11 GW to 78 GW, with some companies shipping more than 10 GW annually.
- Only four of the leading companies in 2010 remain in the top 10 in 2019, and all in the bottom half.
- New companies moved to top spots in a relatively short amount of time, in part through the rapid growth of mono c-Si production.
- Tongwei produced 1 GW in 2014 and recently announced plans to open a new 30 GW cell manufacturing facility.
- Aiko, founded in 2009, recently announced plans to build a 45 GW manufacturing facility by 2022.
- LONGi gained significant market share through its rapid scale-up of mono-crystalline wafer manufacturing (with currently over 45 GW of wafering capacity).

**\*Note:** Excludes inventory sales and outsourcing.

**Source:** 2010-2019: Paula Mints. "Photovoltaic Manufacturer Capacity, Shipments, Price & Revenues 2019/2020." SPV Market Research. Report SPV-Supply8. April 2020.

# PV Manufacturers' Margins



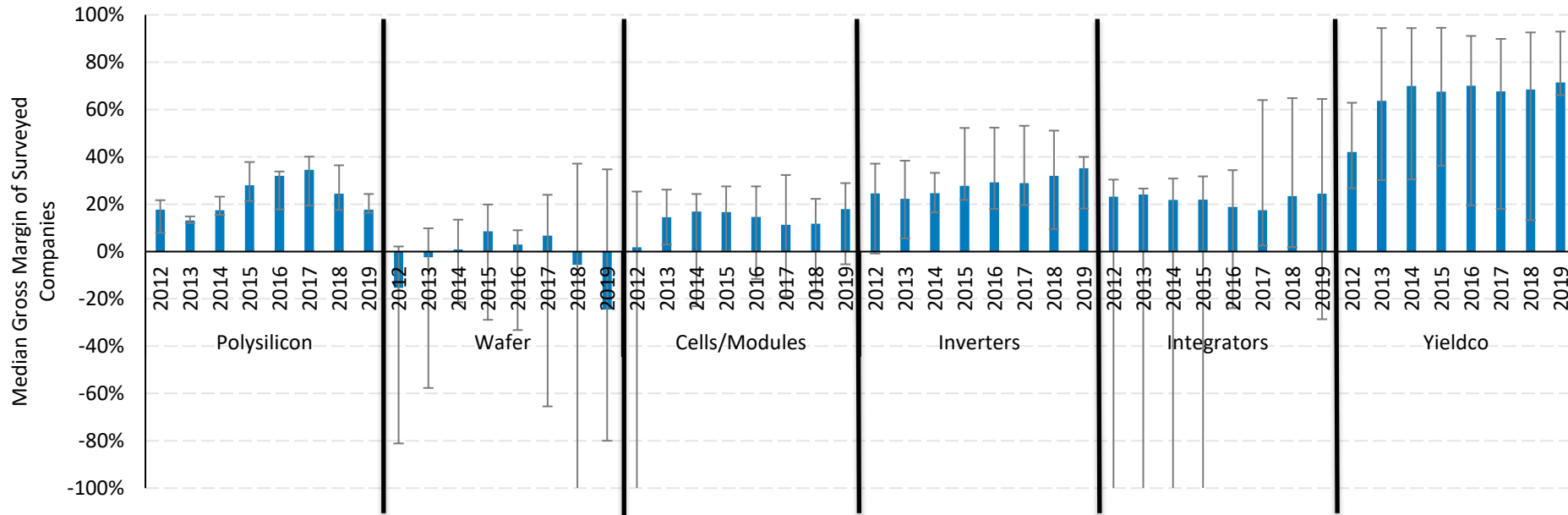
Line represents the median, with error bars representing 80<sup>th</sup> and 20<sup>th</sup> percentiles for the following companies in Q1 2020: Canadian Solar, First Solar, LONGi, Motech Industries, United Renewable Energy, ReneSola, Shunfeng, Tongwei, Risen Energy, and SunPower. Margin data from Hanwha Q Cells, Jinko Solar, JA Solar, Trina, and Yingli are also included from Q1 2010 to Q4 2019 where available.

- The median gross margin of the publicly traded PV companies represented to the left declined in Q1 2020, however margins for this set of companies are still at relatively high levels historically.
- There continues to be significant variation by individual companies as individual factors come into play.

# Gross Margin Across Supply Chain

- In 2019, gross margins were mixed in the PV industry with variations by/within each segment of the supply chain.

- Polysilicon and wafer manufacturers generally had lower gross margins from 2017 to 2019, while module, cell, and inverter manufacturers' gross margins improved.
- Integrators and yieldcos also improved gross margins in 2019.

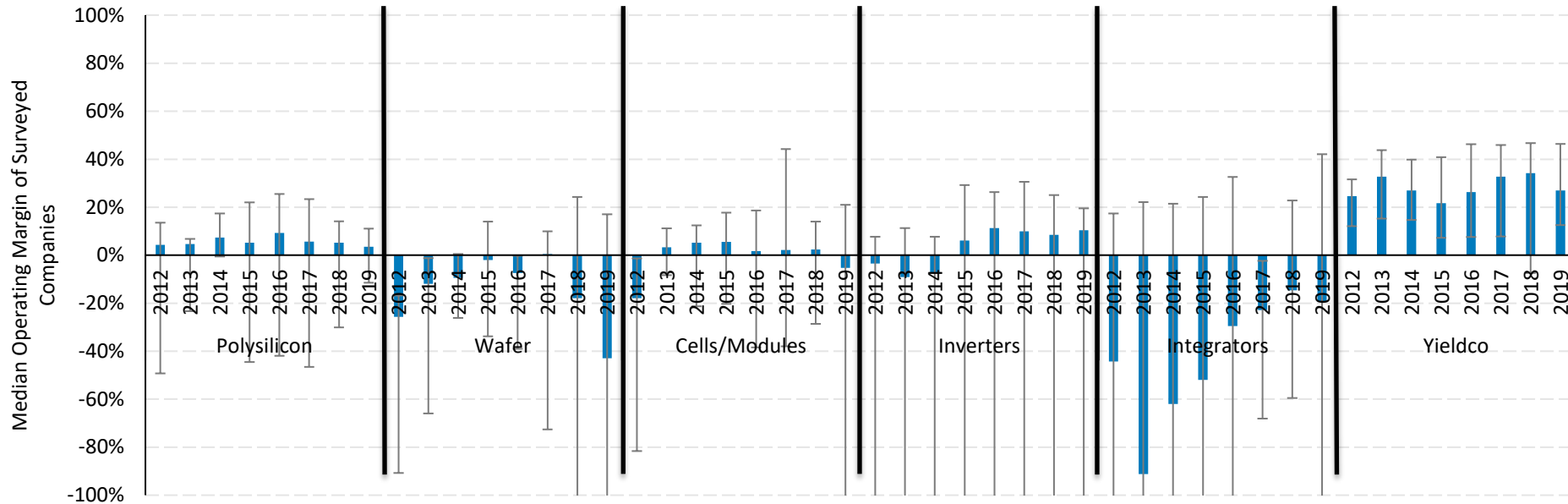


Sources: Company figures from public filings and finance.yahoo.com. Error bars represent high and low values of surveyed companies. Companies surveyed are: Polysilicon – GCL Poly, REC Silicon, Wacker Chemie, Ferroglöbe; Wafers - ReneSola, Wafer Works Corp, Danen Technology Group, Green Energy Technology Inc; Cells/Modules, Gintech, United Renewable Energy Corp, Motech, First Solar, JA Solar, Yingli, Trina Solar, Canadian Solar, PV Crystalox Solar, Hanwha Solar One, Jinko Solar, SunPower, LONGi, Tongwei; Inverters – SolarEdge; Enphase; SMA Solar; Advanced Energy Industries; Integrators - Real Goods Solar, SolarCity, Vivint Solar, Sunrun, Sunworks, Enlight Renewable Energy, Sunnova; IPP/Yieldco - Brookfield Renewable Partners; Algonquin Power & Utilities Corp; Clearwater Energy, Northland Power, Pattern Energy, Terraform Power, TransAlta Renewables.

# Operating Margin Across Supply Chain

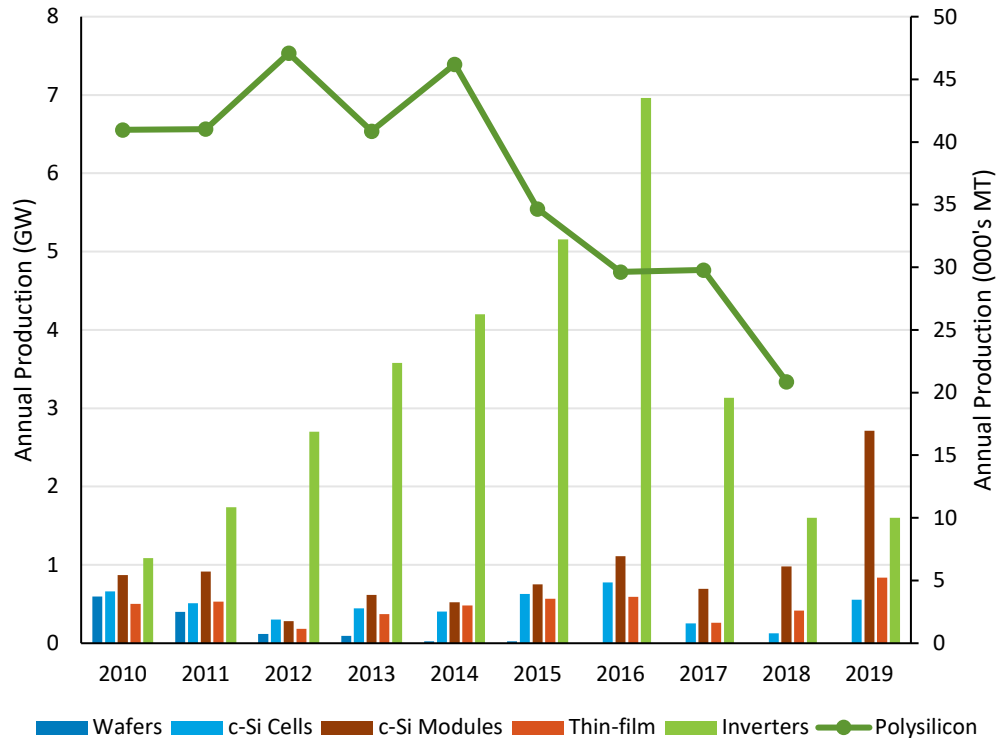
- Despite improved gross margins, cell and module manufacturers lost money, on average, in 2019.
  - Wafers were the worst-performing segment.
- 2019 was the first year since 2013 that integrators did not narrow their losses, on average.

- Operating margin is not necessarily an indicator of corporate profitability, although with strong margins, companies should eventually find a way to profitability.



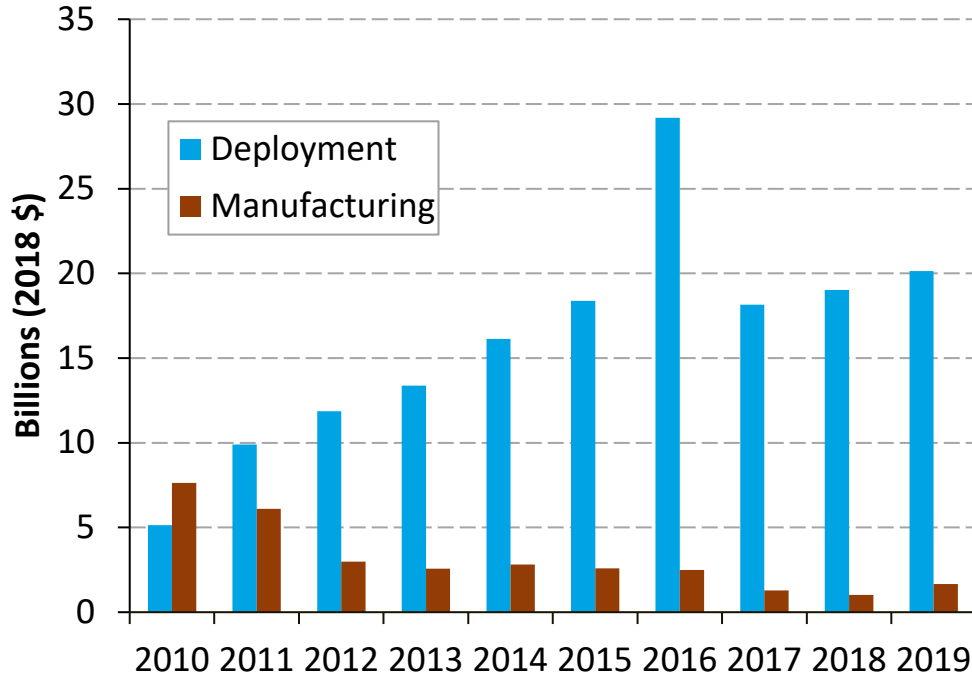
Sources: Company figures from public filings and finance.yahoo.com. Error bars represent high and low values of surveyed companies. Companies surveyed are: Polysilicon – GCL Poly, REC Silicon, Wacker Chemie, Ferroglöbe; Wafers - ReneSola, Wafer Works Corp, Danen Technology Group, Green Energy Technology Inc; Cells/Modules, Gintech, United Renewable Energy Corp, Motech, First Solar, JA Solar, Yingli, Trina Solar, Canadian Solar, PV Crystalox Solar, Hanwha Solar One, Jinko Solar, SunPower, LONGi, Tongwei; Inverters – SolarEdge; Enphase; SMA Solar; Advanced Energy Industries; Integrators - Real Goods Solar, SolarCity, Vivint Solar, Sunrun, Sunworks, Enlight Renewable Energy, Sunnova; IPP/Yieldco - Brookfield Renewable Partners; Algonquin Power & Utilities Corp; Clearwater Energy, Northland Power, Pattern Energy, Terraform Power, TransAlta Renewables.

# U.S. Module and Cell Manufacturing



- From 2010-2019, U.S. manufacturers faced varying degrees of challenges:
  - PV-assembled modules stagnated for most of the past decade before scaling up significantly in 2019.
  - Production of cells varied year to year, however cell producers suffered a series of bankruptcies in 2018. In 2019, cell production started to rebound, but in 2020, most cell production has stopped.
  - Wafer production in the United States ended in 2015.
  - China placed tariffs on U.S.-produced polysilicon in 2014, cutting off most buyers and significantly reducing sales. It is unclear how much, if any, solar-grade polysilicon is currently being produced in the United States.
  - U.S. inverter manufacturing grew with increasing U.S. demand, however due to economic pressures, many manufacturers closed U.S. plants to consolidate operations in Europe or manufacture in China.
- Other PV hardware manufacturing in the United States have also experienced fluctuations over time.
  - For example, the U.S. company NextTracker, the largest global tracking manufacturer, was purchased by Flex and has shifted its manufacturing outside the United States.

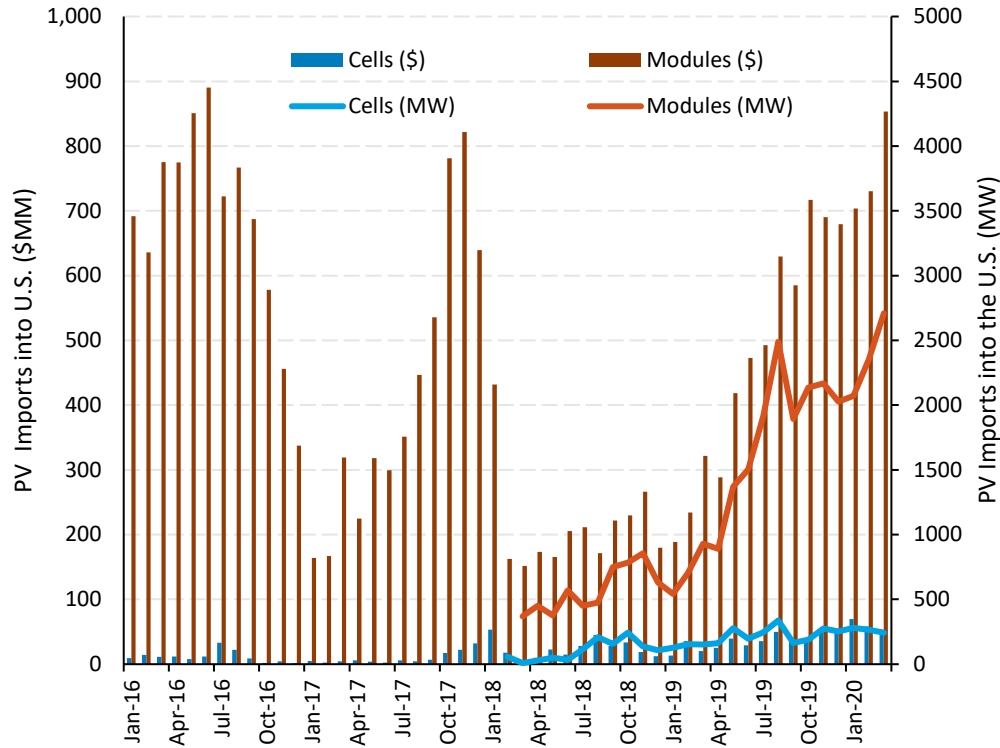
# Revenue of U.S. PV



- In 2010, revenue from PV manufacturing was greater than revenue from PV deployment.
- Between 2010 and 2019, as manufacturing revenue declined, revenue from PV deployment increased.
- In 2019, revenue from PV deployment was more than 10X revenue from PV manufacturing.

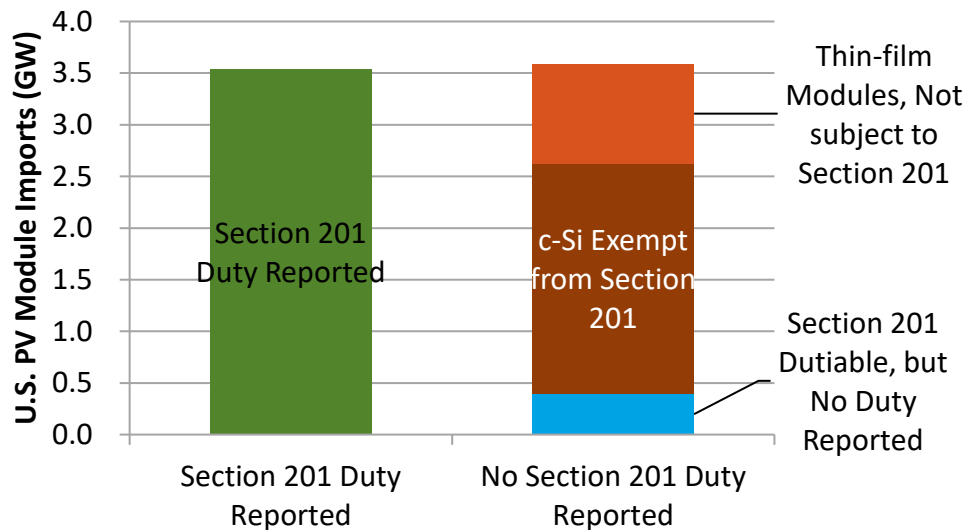


# Module and Cell Import Data



- Despite tariffs, PV modules and cells are being imported at historically high levels.
  - 7.1 GW of PV modules were imported in Q1 2020.
  - Another 0.8 GW of cells were imported in Q1 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 produce in Q1 2020.
  - First Solar reported operating at 75% capacity in late March and April.
- The United States imported a little more than 250 MW of PV cells per month in Q1 2020, which would translate into about 3 GW per year. SEIA reported that at the end of 2019, the United States had 6.8 GW of PV module assembly capacity, implying that the industry was operating around 45% utilization rate.

# Q1 2020 Module Imports by Tariff

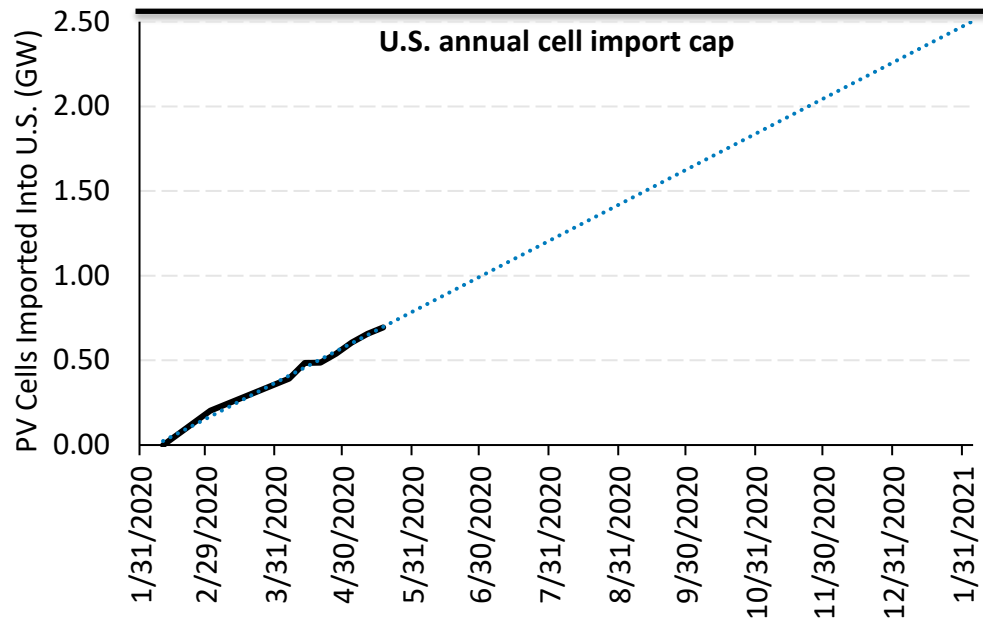


- In Q1 2020, 3.5 GW of imported PV modules did not report a tariff.
  - Historically most of these modules were thin-film, but in Q1 2020, most of these modules (2.2 GW) reported to be c-Si and exempt from the Section 201 duties—mostly from South Korea, Vietnam, Thailand, and Malaysia.
  - Most of these were likely bifacial modules, which were exempt in Q1 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. The court directed the administration to set a schedule for further proceedings by June 17.
  - For approximately 0.4 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.”

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

# 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-May 2020 trend continues through the remainder of the period, the United States would just exceed the 2.5 GW by February 2021, as it has imported approximately one-quarter of the quota in one-quarter of the period.
- Approximately 20%-25% 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

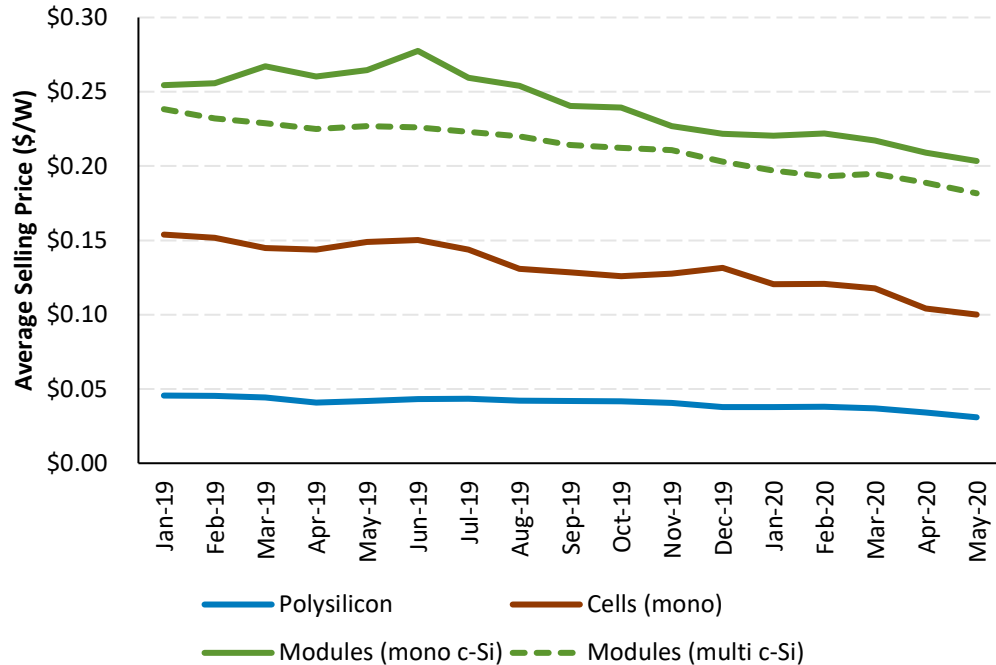
- 5 Global Manufacturing

- 6 Component Pricing**

- Market Activity

- Global module and module-component prices continued their declines in the first five months of 2020, with BNEF reporting mono c-Si modules down 8% to 0.21/W, multi c-Si modules down 11% to \$0.19/W, cells down 24% to \$0.10/W, and polysilicon down 18% to \$6.5/kg.
- 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 75% premium over global module ASP.

# PV Value Chain Spot Pricing

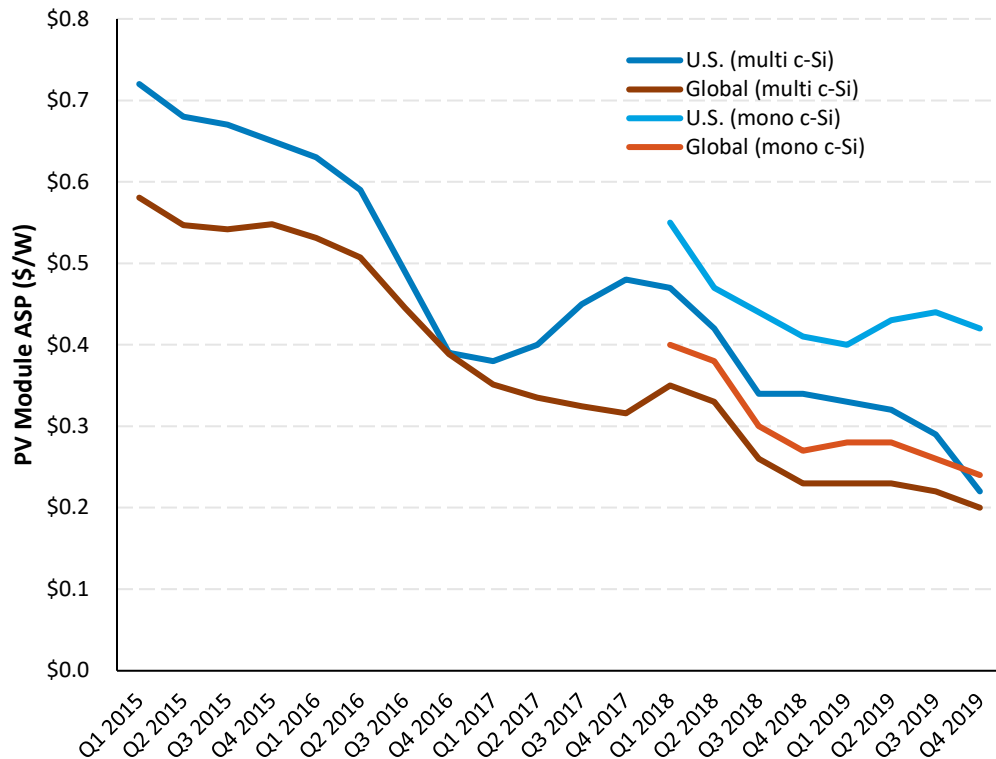


- Global module and module-component prices continued their price declines in the first five months of 2020, with BNEF reporting mono c-Si modules down 8% to 0.21/W, multi c-Si modules down 11% to \$0.19/W, cells down 24% to \$0.10/W, and polysilicon down 18% to \$6.5/kg.
- PVInsights reported average module prices below \$0.17/W.

Source: BNEF Solar Spot Price Index (05/27/20).

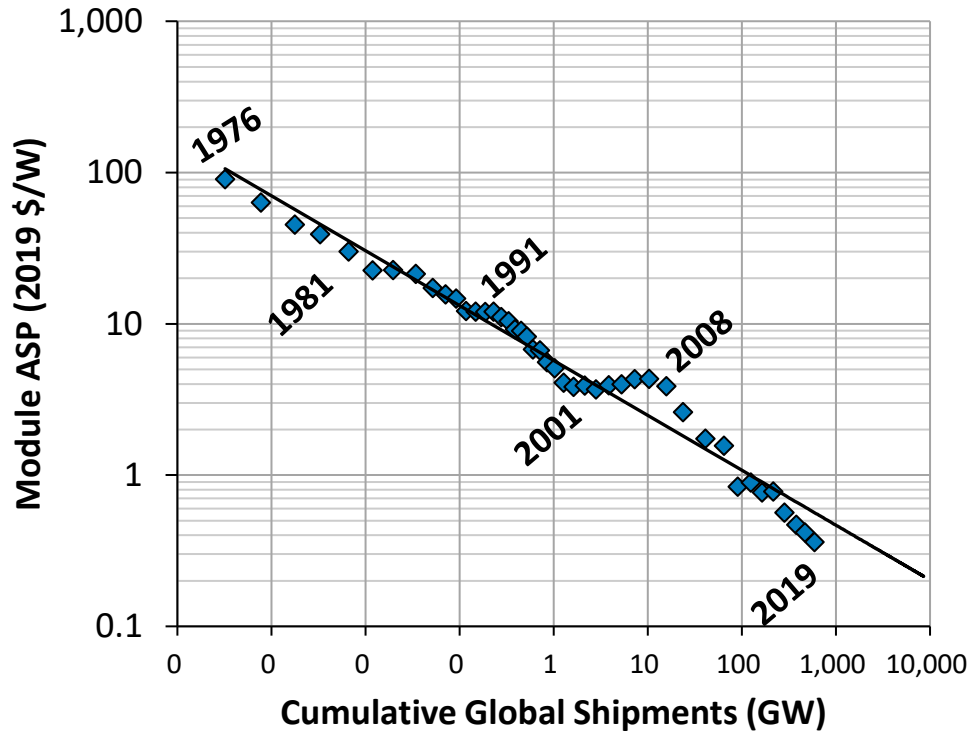
Kilogram to Watt conversion: 4.78 grams per watt (2016); 4.73 grams per watt (2017, 2018, 2019, 2020), from Cowen & Co. (05/11/17); Deutsche Bank (07/19/17).

# Module Average Selling Price: Global versus United States



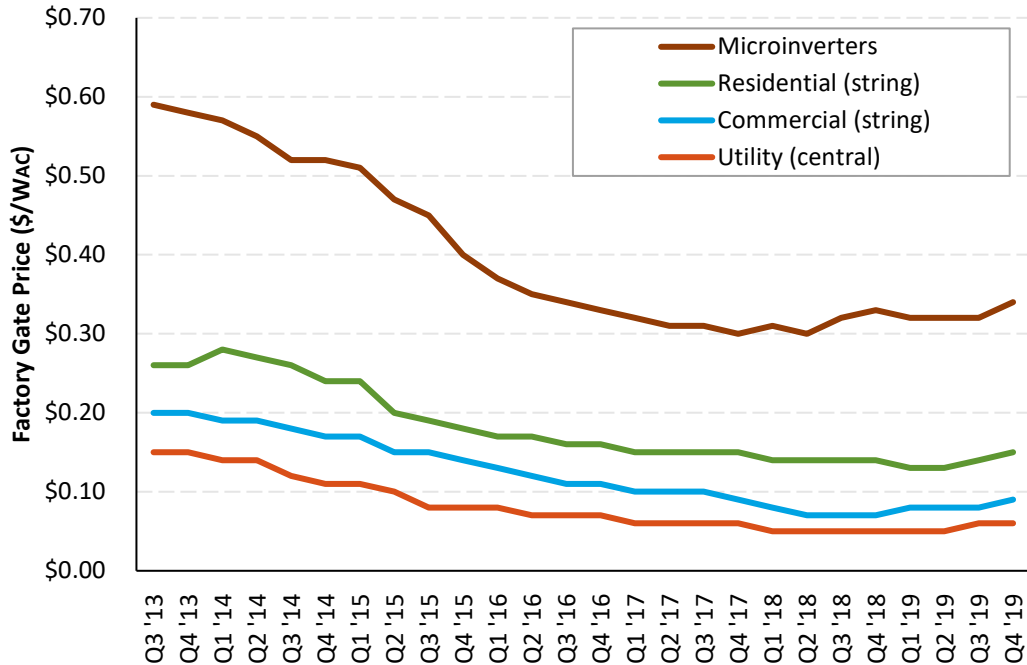
- In Q4 2019, U.S. mono c-Si module prices fell, dropping close to their lowest recorded level, but they were still trading at a 75% premium over global ASP.
  - U.S. multi c-Si module prices dropped precipitously due to significant lack of demand, though are still above global pricing.
  - In Q1 2020, it is likely U.S. pricing will drop further, given the reduction in tariffs in February.

# PV Experience Curve



- This experience curve displays the relationship, in logarithmic form, between the average selling price of a PV module and the cumulative global shipments of PV modules.
- For every doubling of cumulative PV shipments between 1976-2019, there has been on average a ~22% reduction in PV module price.
- Since 2008, the PV industry has experienced accelerated improvements, putting module ASPs below the historical experience curve since 2012.
  - In 2019, actual module pricing was \$0.36/W, which was well below what the historical experience curve would have suggested (\$0.56/W).

# Inverter Pricing

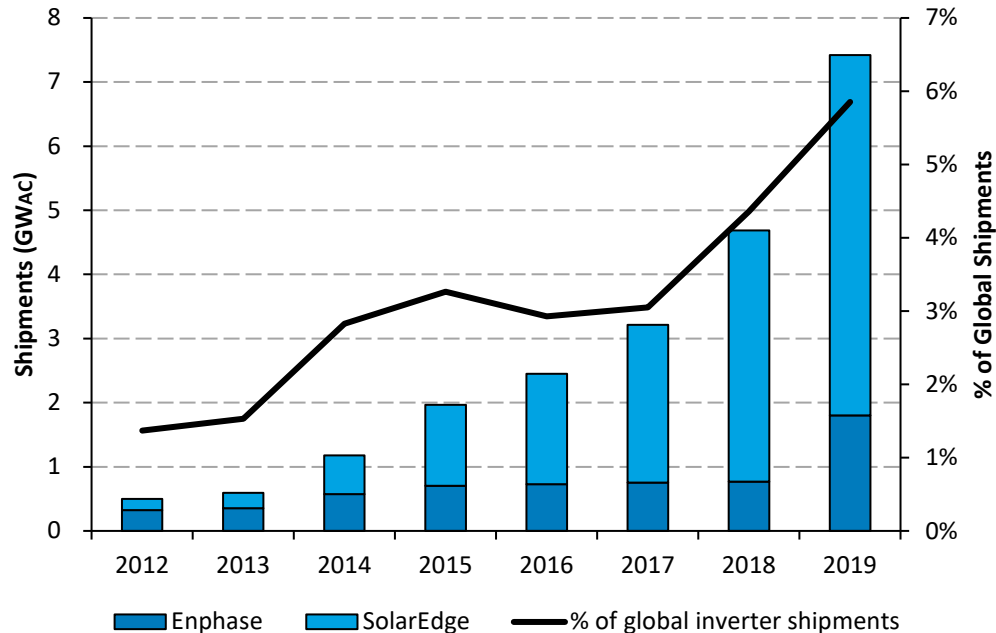


- In 2019, U.S. inverter pricing increased on average 3% for microinverters, 7% for residential string inverters, 29% for commercial inverters, and 20% for utility-scale central inverters.
  - U.S. tariffs on imported Chinese inverters have caused price increases and vendor supply chain realignment.
  - Inverter pricing has stayed in the same range for the past three years.



# Enphase Microinverters and SolarEdge DC-Optimized Inverter Systems

- Enphase and SolarEdge shipped more than 7 GWAC of MLPE combined in 2019, representing approximately 6% of all global inverter shipments.



- The United States represented 54% and 84% of 2019 revenue for SolarEdge and Enphase, respectively.
- From 2015–2018, Enphase shipments were relatively flat but increased 135% in 2019 due to a variety of factors, including: the strong y/y growth of the U.S. residential market; the Master Supply Agreement it entered with SunPower in August 2018; and inverter purchases for ITC safe harbor.
- SolarEdge shipments grew 43% y/y with strong growth in global markets.
- Some analysts expect more growth to come from these companies due to an increased interest in PV+storage, for which these companies have products and continued growth of the U.S. distributed market.



**1** Global Solar Deployment

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**2** CSP Deployment

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**3** U.S. PV Deployment

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**4** PV System Pricing

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**5** Global Manufacturing

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**6** Component Pricing

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**Market Activity**

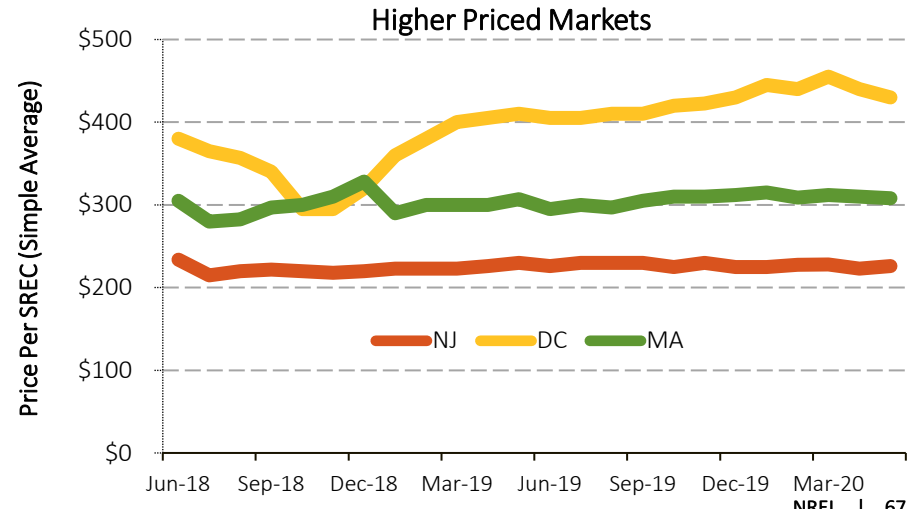
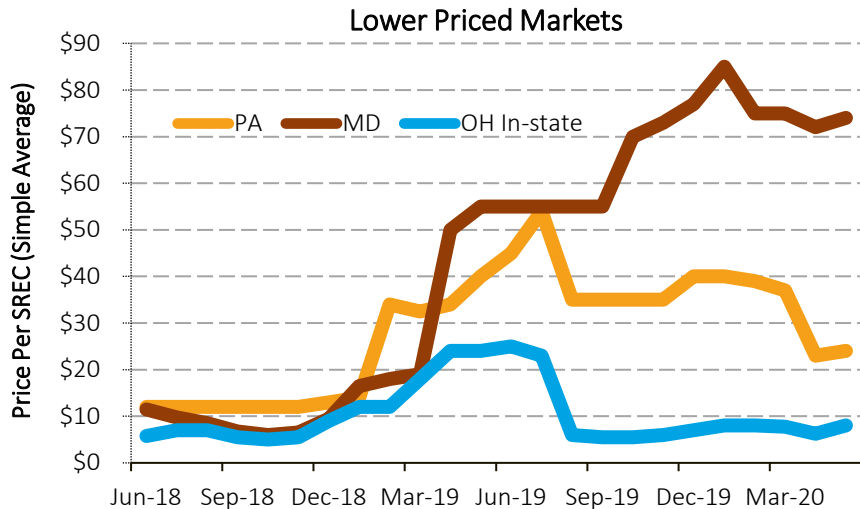
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- Except for Pennsylvania, SREC pricing remained relatively flat in the first five months of 2020.
- In April 2020, New Jersey officially closed its SREC program to new projects after in-state solar generated power reached 5.1% of retail electricity sales.
- Over the past year, solar stocks have generally outperformed the broader stock market and had a better recovery after the downturn in the stock market caused by COVID-19.

# SREC Pricing

- Except for Pennsylvania, SREC pricing remained relatively flat in the first five months of 2020.
  - In 2019, Pennsylvania SREC pricing had increased in expectation of the passage of a bill that would increase solar energy demand, however it has not passed since being introduced in April 2019.

- In April 2020, New Jersey officially closed its SREC program to new projects after in-state solar generated power reached 5.1% of retail electricity sales.
  - The New Jersey SREC program was established in 2004. Since then, over 3.25 GW of solar has been installed in the state.
  - New Jersey is replacing the SREC program in two phases: the first phase is a transitional incentive program adopted in December 2019, followed by a successor program currently under development.

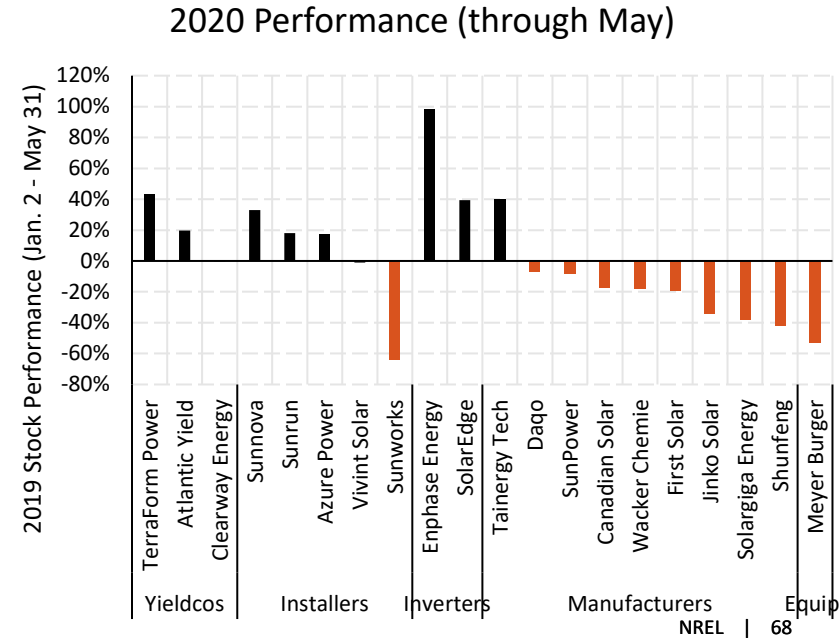
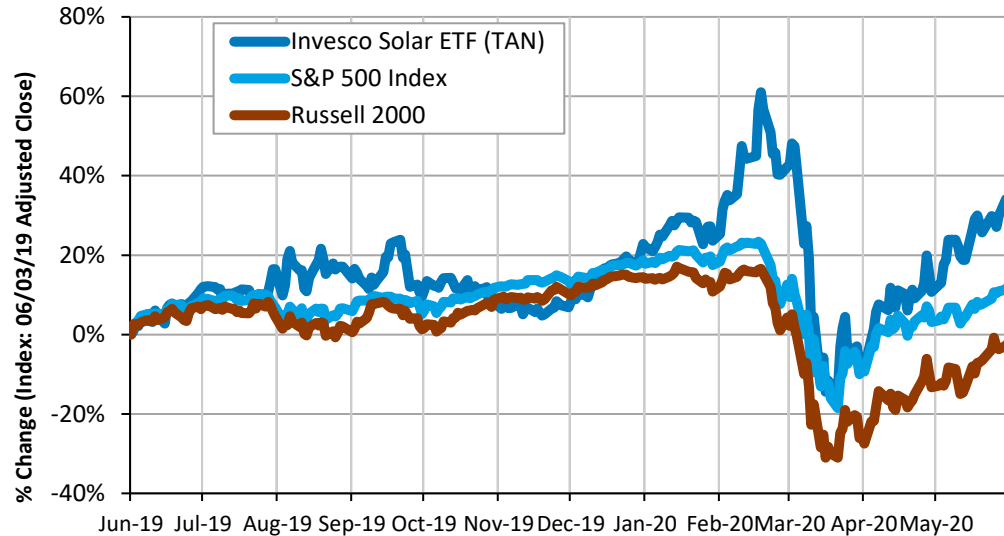


Sources: SRECTrade, <https://www.sretrade.com/>, accessed 06/02/20.

# Stock Market Activity

- Over the past year, solar stocks have generally outperformed the broader stock market and had a better recovery after the downturn in the stock market caused by COVID-19.

- Not all sectors fared the same, with manufacturers losing value and U.S. installers, yieldcos, and MLPE company stocks increasing.



Source: Stock market: Yahoo Finance (06/02/20).

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

# Thank You

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

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# List of Acronyms and Abbreviations

• A-Si	amorphous silicon	• Multi c-Si	multi-crystalline
• AC	alternating current	• MW	megawatt
• ASP	average selling price	• MWh	megawatt-hour
• BNEF	Bloomberg New Energy Finance	• NBFC	non-banking financial company
• CdTe	cadmium telluride	• NEM	net energy metering
• CIGS	copper indium gallium selenide	• Poly	polysilicon
• CIS	copper indium selenide	• PPA	power purchase agreement
• C-Si	crystalline silicon	• PV	photovoltaic
• CSP	concentrating solar power	• R&D	research and development
• DC	direct current	• Q	quarter
• DPV	distributed PV	• REC	renewable energy certificate
• EIA	U.S. Energy Information Administration	• ROW	rest of world
• Equip	Equipment	• RPS	renewable portfolio standards
• ETF	exchange traded fund	• S&P	Standard and Poor's
• EU	European Union	• SG&A	selling, general, and administrative expenses
• FIT	feed-in-tariff	• SE	southeast
• FTM	front-of-the-meter	• SEIA	Solar Energy Industries Association
• G&A	general and administrative expenses	• SREC	solar renewable energy certificate
• GW	gigawatt	• TAN	Invesco Solar ETF
• IRP	Integrated resource planning	• TPO	third-party owner
• ITC	investment tax credit	• TW	terawatt
• kg	kilogram	• TWh	terawatt-hour
• kW	kilowatt	• UPV	utility-scale PV
• kWh	kilowatt-hour	• W	watt
• MLPE	module-level power electronics	• y/y	year over year
• Mono c-Si	mono-crystalline	• YTD	year to date