

Q3/Q4 2018 Solar Industry Update

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Executive Summary

- By the end of 2018, Hawaii, California, the District of Columbia, 104 cities, 11 counties, and 51 American companies in the United States had made 100% clean power commitments.
 - In 2018, renewables generated more electricity (41%) in Germany than coal (38%)—a first.
 - An IEA report projects 4.3 GW-AC of global CSP installations from 2018 to 2023.
 - EIA estimates 23% of all new electricity generating capacity in the United States came from solar installations in 2018—second to natural gas.
 - Utility-scale PV contributed 39% to Q3 2018 U.S. PV installations—its lowest level since Q1 2012. Wood Mackenzie attributes the low level of utility-scale PV installation to uncertainty of the impacts of the Section 201 tariff in 2017.
 - In January 2019, the California IOU PG&E declared bankruptcy;
- it is uncertain how this development might impact utility-scale solar PPAs signed within the past several years.
- Roughly 3 GW of new or refurbished U.S. PV manufacturing capacity is expected to come online in 2019. Historically, actual production capacity brought online has often taken longer and/or been lower than originally reported.
 - In January 2019, global module ASP was reported to be \$0.22/W.
 - In 2018, solar stocks were down 28% compared to -1% performance by the S&P 500 Index.
 - 2018 global and U.S. solar investment were \$132B and \$21B respectively—the vast majority of which went to project deployment.
- A list of acronyms and abbreviations is available at the end of the presentation.**



1 State and Federal Updates

2 Global Solar Deployment

3 U.S. PV Deployment

4 PV System Pricing

5 Global Manufacturing

6 Component Pricing

7 Market Activity



1 State and Federal Updates

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4 PV System Pricing

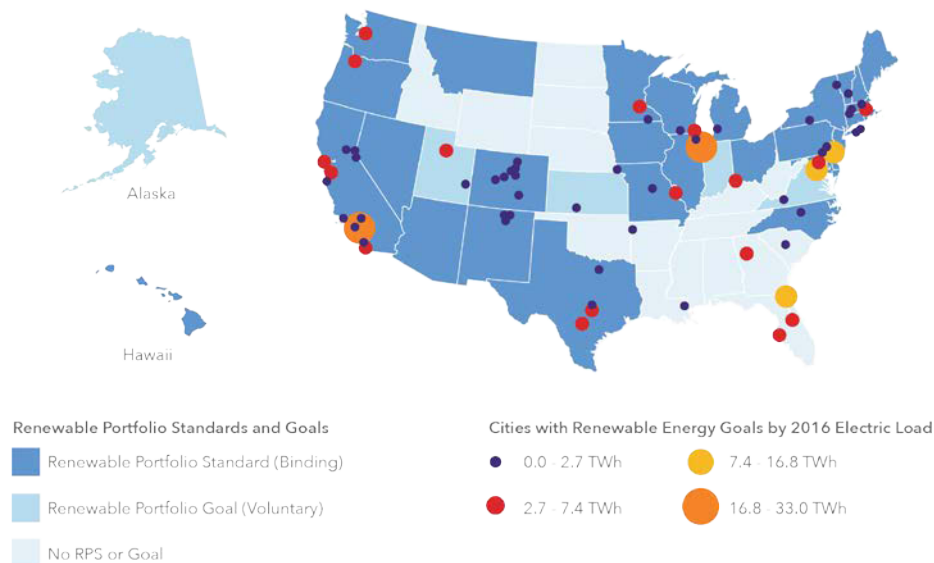
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7 Market Activity

By the end of 2018, Hawaii, California, the District of Columbia, 104 cities, 11 counties, and 51 American companies all over the United States made commitments to 100% clean power.

States, Cities, and Counties Ramping Up Clean Energy Goals





Goals range from 12.5% in Ohio and North Carolina to 100% in several states, territories, counties, and cities.

- Non-federal U.S. actors have increased efforts for clean energy deployment.
 - A recent report titled *America's Pledge* estimates clean energy commitments by states, cities, and businesses could increase demand for non-hydro renewable energy generation to 500 TWh by 2025—enough to power 56 million homes for a year.
- While the technical feasibility for 100% renewable electricity is currently being debated by the scientific community, many policymakers and corporate leaders have pushed for aggressive clean energy targets, including some with 100%.

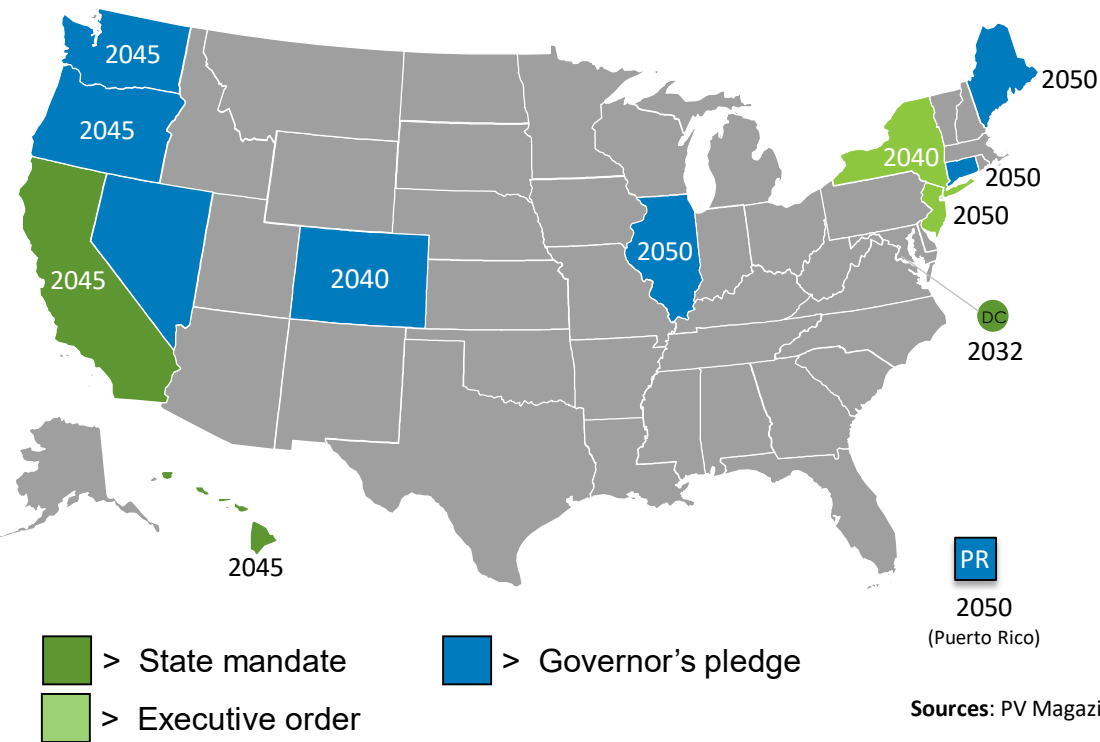
Cities with 100% Clean Electricity Commitments



-  **Powered by 100% Renewable Energy:** These communities have currently achieved their 100% clean, renewable electricity targets.
-  **Committed to 100% Renewable Energy:** These communities have made community-wide commitments to transition to 100% clean, renewable electricity by no later than 2050.

- By the end of 2018, 104 cities and 11 counties all over the United States had made 100% clean power commitments.
 - Fifty million people, or over 15% of the U.S. population, now live in these places.
 - Notable clean energy commitment announcements in 2018 include a number of major cities, including Minneapolis, Cincinnati, Denver, and Berkeley.
- Six cities have already achieved their 100% clean power targets.
- Most commitments have a target date between 2030 and 2050.

States' Commitments to 100% Clean Electricity



- In 2018, California and Washington, D.C. joined Hawaii in committing to 100% clean power.
- Additionally, the governors of New Jersey and New York signed executive orders, and eight governors made pledges (CO, CT, IL, MA, ME, OR, PR, and WA) to achieve 100% clean electricity.
 - In 2017, these 13 jurisdictions consumed more than 18% of U.S. electricity.
- All these commitments have a target date between 2030 and 2050.

Private Sector Commitments to 100% Renewable Energy

- Companies have also made similar commitments to 100% renewable energy.
 - With 158 members globally, the non-profit *RE100* commits businesses to 100% renewable power for their global operations.
 - Last year, 10 new American companies joined the RE100 initiative, increasing the number of American companies to 51.
 - Currently, these U.S. businesses consume over 29 million MWh of electricity per year, 56% of which is currently supplied from renewable sources.
 - The United States is the most represented country in the RE100.
 - A large share of RE100 companies operate in the banking and consumer sectors.
 - To achieve 100% renewable energy, U.S. companies in most cases opt to purchase unbundled RECs or sign a PPA. Self-generation is still not widely practiced.
- A 2018 survey found business executives believe that committing to renewable energy targets strengthened their brand reputation.
- Outside the RE100 project, businesses were making similar pledges.
 - Sony committed to achieving 100% renewable energy for its North American operations.
 - Xcel was the first utility to announce it will be carbon-free by 2050.
 - In 2017, they were the provider for 55% and 47% of the customers in Colorado and Minnesota respectively. They also provide service in Michigan, New Mexico, North Dakota, South Dakota, Texas, and Wisconsin.



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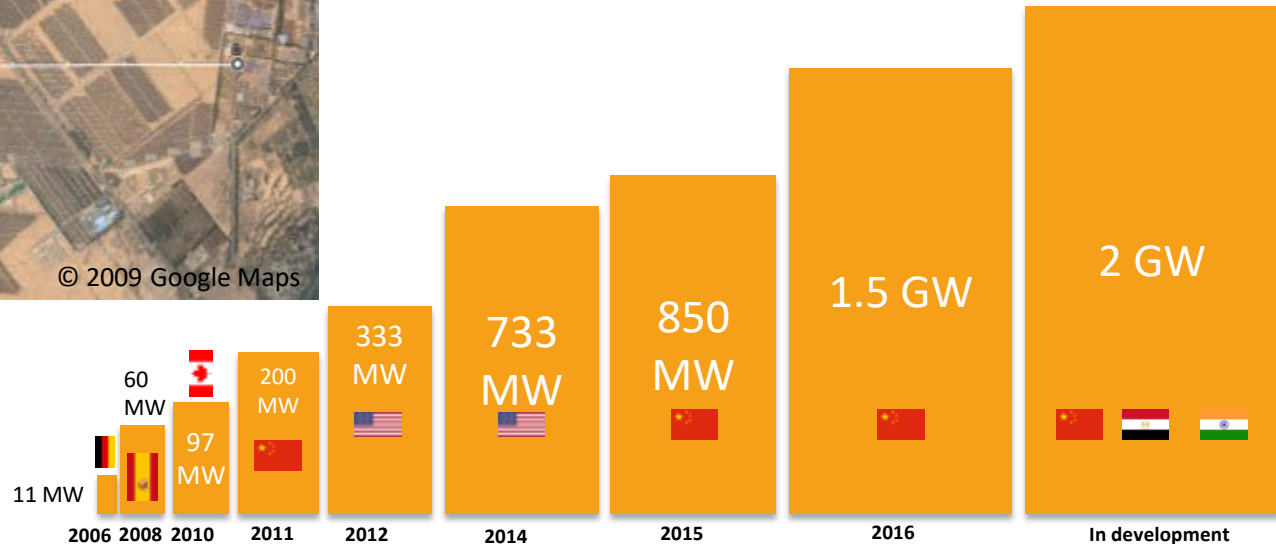
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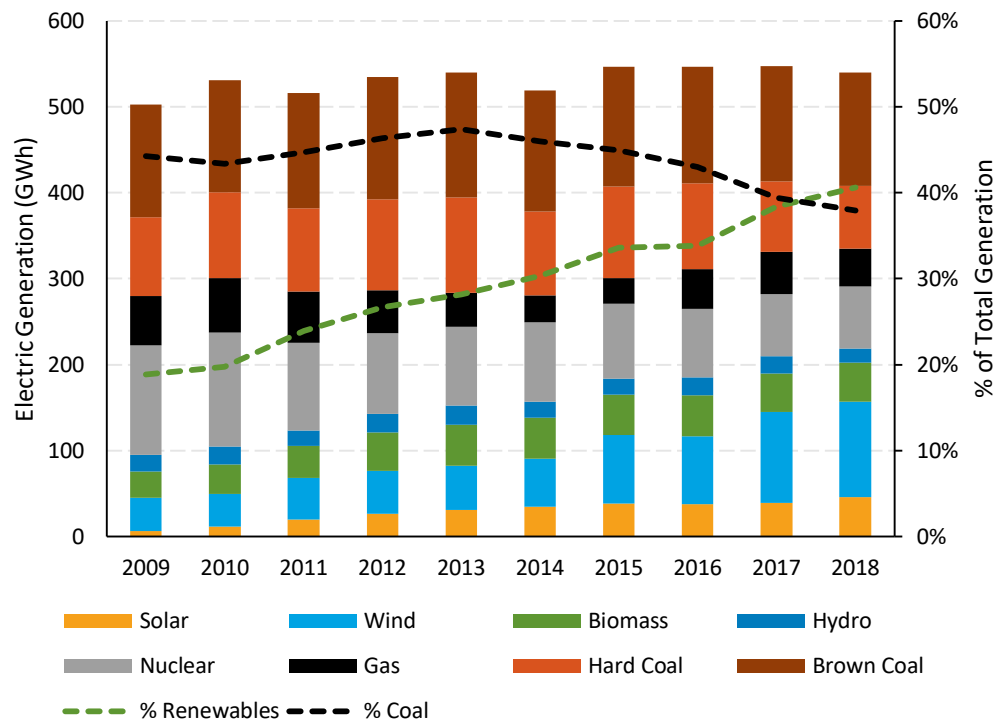
- Currently, the largest solar PV system in the world is a 1.5-GW facility in China; however, 2 GW-projects (or parks) are in development in Egypt, India, and China.
- In 2018, renewables generated more electricity (41%) in Germany than coal (38%)—a first.
- An IEA report projects 4.3 GW-AC of global CSP installations from 2018 to 2023.

World's Largest PV System

- In 2006, the largest PV system in the world was an 11-MW facility in Germany.
- Currently, the largest PV system in the world is a 1.5-GW facility in China; however, 2-GW projects (or parks) are in development in Egypt, India, and China.



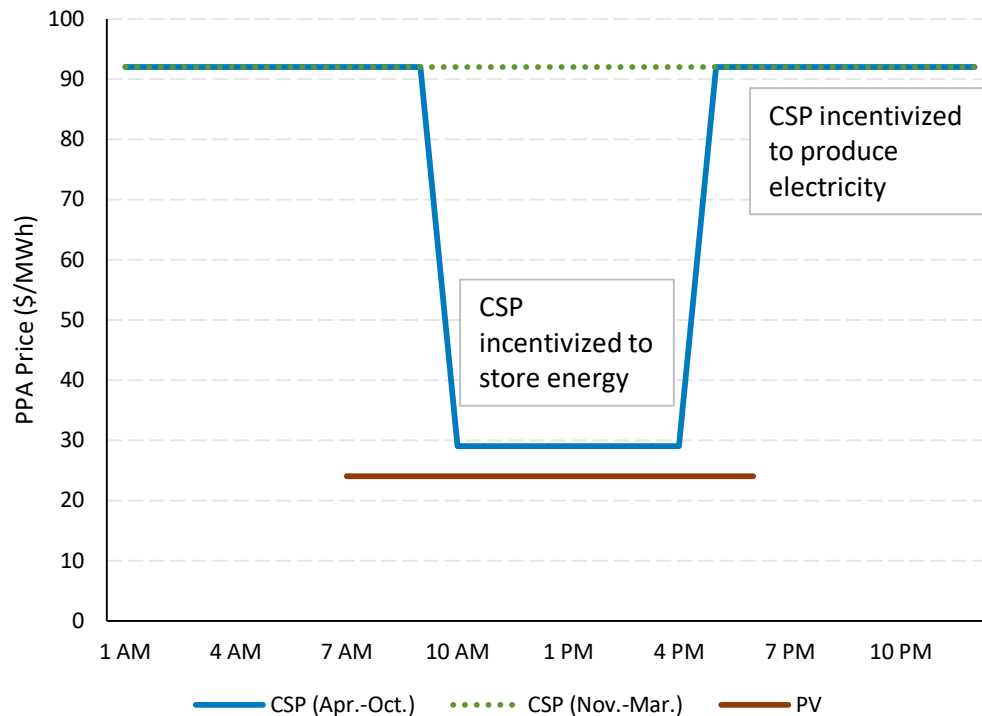
German Electricity Generation by Source



- In 2018, renewables generated more electricity (41%) in Germany than coal (38%)—a first.
 - From November 2017 to October 2018, the United States generated 18% from renewables and 27% from coal.
- An increase in solar generation in Germany coincided more with a decrease in nuclear electricity production than a decrease in coal production.
 - From 2009 to 2014, solar generation increased 28 GWh, while nuclear generation decreased 36 GWh.
 - Electricity from coal actually increased 16 GWh over the same period.
- The drop in electricity from coal coincided more with an increase in wind than an increase in solar.
 - From 2014 to 2018, wind and solar generation increased 55 GWh and 11 GWh, respectively, while coal and nuclear generation decreased 34 GWh and 20 GWh, respectively.

Recent Developments in CSP Sector

PV and CSP

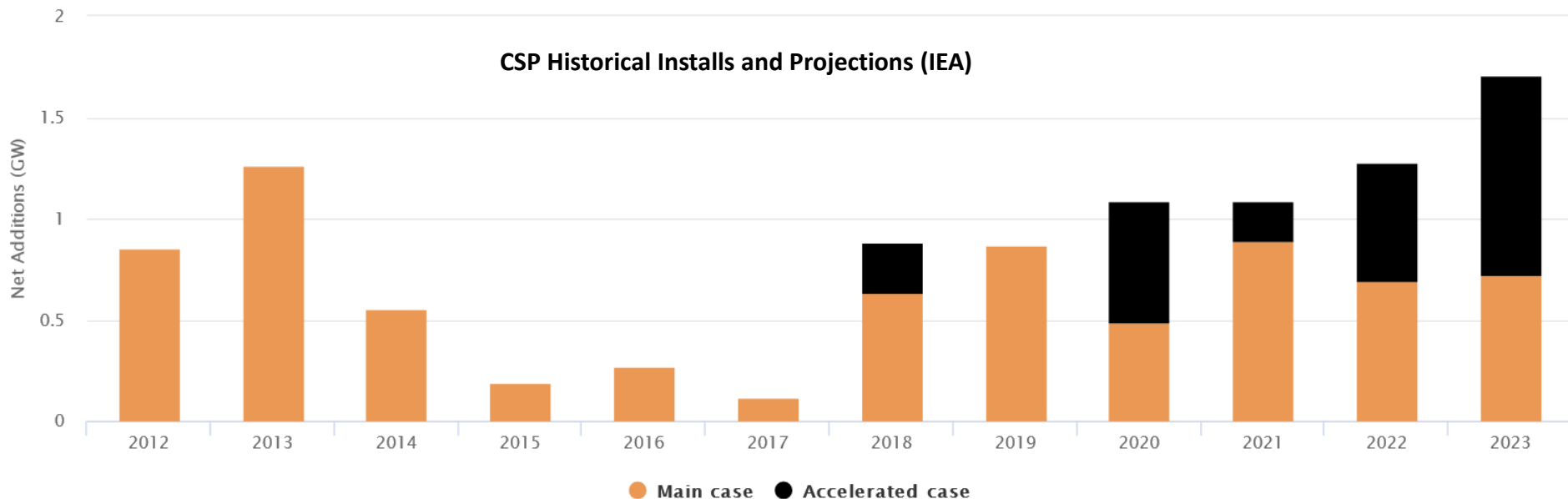


- In December 2018, the Dubai Electricity Water and Authority (DEWA) announced it would add 250 MW-AC of PV to its 700 MW-AC Mohammed bin Rashid Al Maktoum CSP project.
 - The CSP plant, with 15 hours of storage, was awarded at a record low PPA price of \$73/MWh (\$29/MWh from 10AM – 4PM in the seven-month summer period, \$92/MWh at other times).
 - The PV plant was also awarded a PPA price of \$24/MWh
 - The PPA is structured to encourage CSP energy storage during the day, relying more heavily on PV production for the daytime.
 - Morocco also believes there are valuable coupling gains with a hybrid CSP-PV project, and it is in the final stages of tendering a PPA, which New Energy Update believes could be at a record low level.

Recent Developments in CSP Sector

IEA Projections, 2018–2023

- In October 2018, the IEA released its *Renewables 2018* report, in which they project 4.3 GW-AC of CSP will be installed from 2018 to 2023 in its main case, and 6.9 GW-AC under an accelerated scenario.
- IEA projects most installations will come from China (1.9 GW), Morocco and South Africa (1 GW), and the Middle East (1 GW).
- This represents 32% faster growth for CSP than from 2012 to 2017.



Recent Developments in CSP Sector

Enhanced Oil Recovery



- GlassPoint signed a memorandum of understanding to develop a 2 GW-th solar thermal plant for enhanced oil recovery in Oman.
 - GlassPoint is already developing a 1 GW-th solar thermal plant for enhanced oil recovery in Oman and is already supplying steam from 4 of the 36 planned generation blocks.



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- Utility-scale contributed 39% to Q3 2018 installations, its lowest level since Q1 2012. Wood Mackenzie attributes the low level of utility-scale installation to uncertainty of the impacts of the Section 201 tariff in 2017.
- At the end of October, there were 47.0 GW-AC of solar PV systems in the United States, of which 28.0 GW were utility-scale PV and 19.0 GW were distributed PV.
- In January 2019, the California IOU PG&E declared bankruptcy, putting into doubt higher-priced PPAs from PV systems signed several years ago.

PG&E Declares Bankruptcy

Sources: BNEF (01/18/19); NBC News (01/14/19); Financial Times (01/21/19); New York Times (01/17/19); SEPA (2018 Utility Solar Market Snapshot).

- In January 2019, the California IOU PG&E declared bankruptcy, due to an estimated \$30B in liability costs related to the company's role in the California wildfires of 2017 and 2018.
 - Until this month, PG&E had been rated investment grade, in part due to the belief that it would seek aid from California. Instead of protection through the legislature, they are seeking protection through the courts.
 - In 2001, PG&E sought Chapter 11 bankruptcy after complications from deregulation.
 - SEPA reports that at the end of 2017 PG&E had the second-most solar of any utility in the country, with just shy of 7 GW-AC, representing 1/6 of all U.S. solar capacity.
- Chapter 11 bankruptcy allows PG&E to continue operations while restructuring financially, meaning they could seek to cancel or renegotiate contracts. PG&E signed many PPAs with solar facilities at much higher prices than current market rates.
 - Credit Suisse estimates PG&E could save \$2.2B a year renegotiating renewable power contracts down to current levels.
 - The contracts include those from projects that have guarantees from the DOE Loan Program on a portion of \$8.3B in loans.
 - Several solar companies that supply PG&E with power (e.g., Con Edison, yieldcos, and Topaz Solar Farms) have been downgraded by ratings agencies or their stock value has fallen.
 - Some experts believe it may be hard for PG&E to renegotiate power contracts, or it may have to pay damages for breach of contract.
 - PG&E currently has enough money to operate.
 - California is aggressively pursuing clean power adoption and canceled contracts might scare potential investors.

PV Curtailment: Contract Structures

Existing PPA structures generally address curtailment in one of three ways:

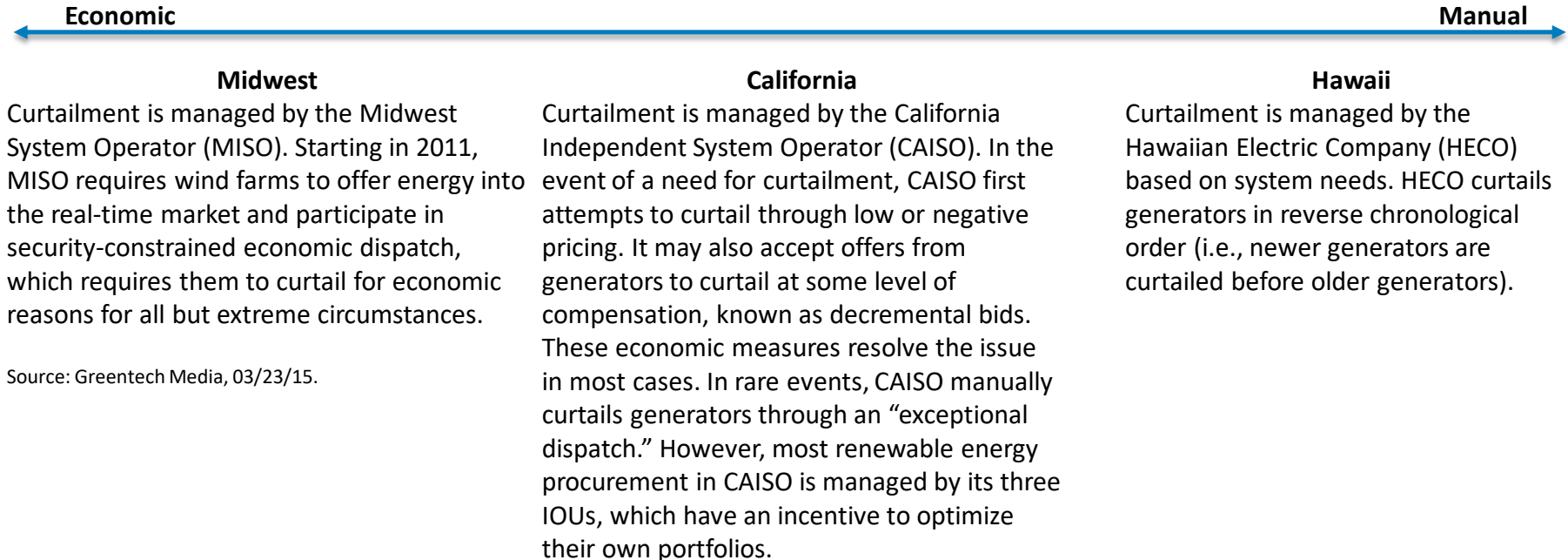
- **Take-or-pay:** The offtaker agrees to buy all output—delivered and curtailed—at the settled PPA rate.
- **Reduced take-or-pay:** The PPA contract terms include separate rates for delivered PV output and curtailed PV output, with the curtailed rate being lower than the delivered rate. Alternatively, the offtaker may only compensate for curtailment under certain conditions (e.g., for economic curtailment but not for exceptional dispatches).
- **Non-compensable curtailment:** The offtaker only pays for delivered energy; the generator bears the full risk of curtailment.

New PPA structures are being explored that would impact the distribution of curtailment risk between the offtaker and the generator, including:

- **Capacity plus energy PPA:** The offtaker pays the generator a fixed capacity (\$/MW) rate in addition to the standard volumetric (\$/MWh) rate.
- **Fixed lease:** The offtaker pays a fixed monthly lease rate to fully control the generator.

PV Curtailment: Implementation

Curtailment has been increasing in the Midwest (for wind) and California and Hawaii (for PV). The implementation of curtailment varies in these three regions.



Source: Greentech Media, 03/23/15.

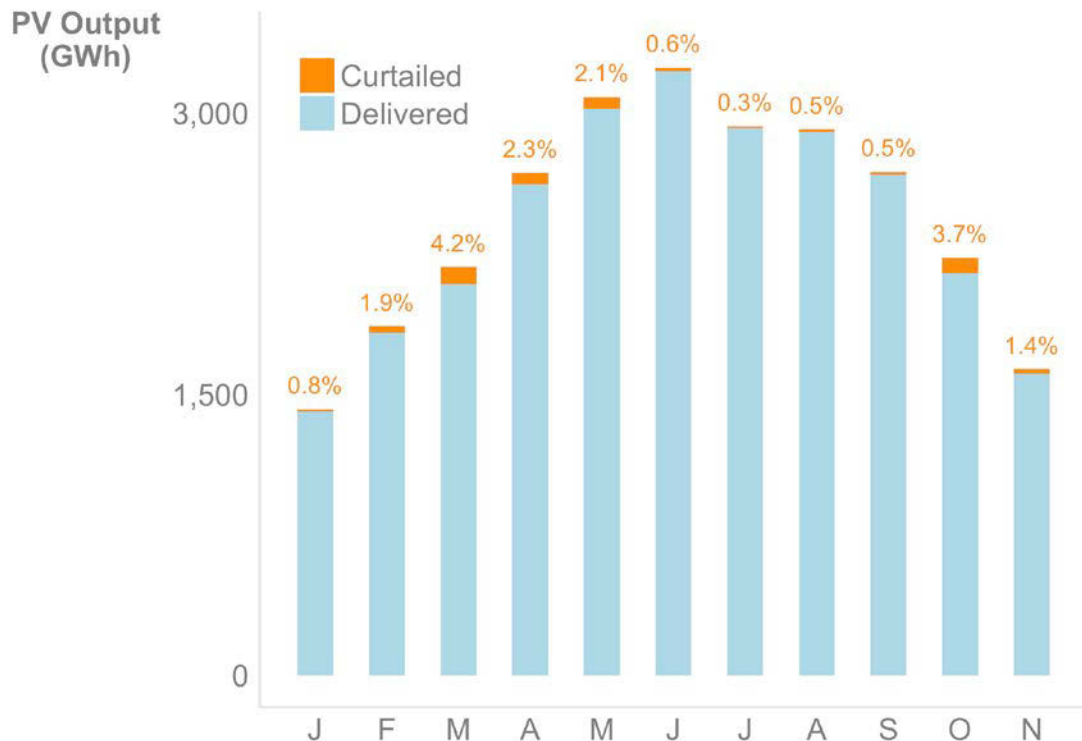
PV Curtailment: Trends to Date

California

- CAISO curtailed about 420,000 MWh of PV output in 2018—about 1.6% of systemwide PV output.
- PV curtailment was highest in the spring when hydropower capacity peaked and electricity demand was relatively low.

Hawaii

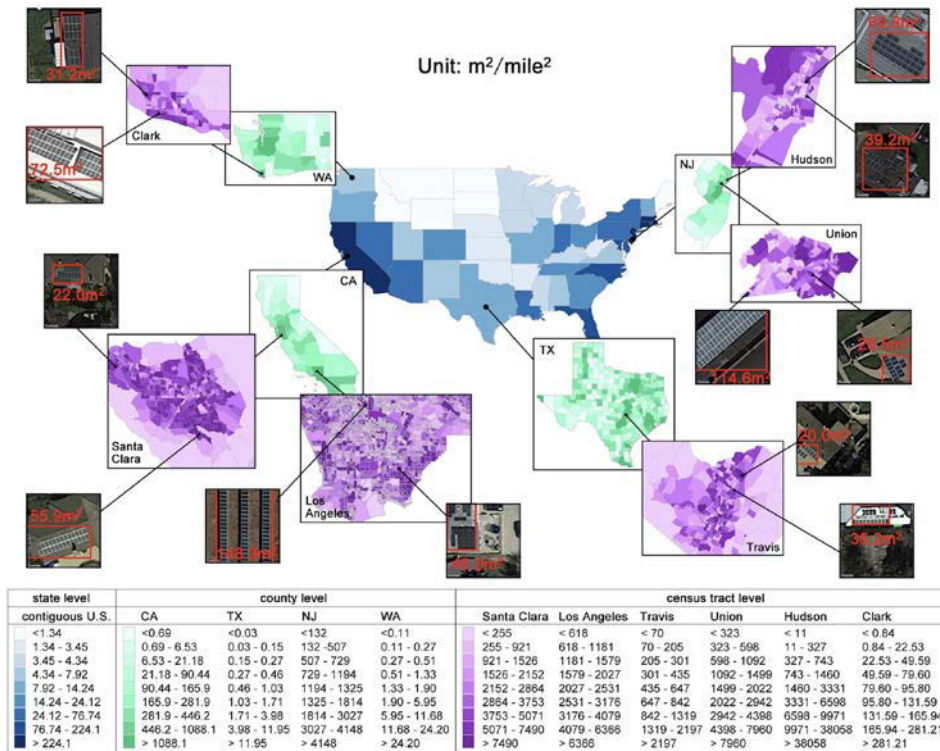
- By one estimate, expected curtailment levels for new PPAs are about 10% on O'ahu, and 20%–50% on Maui and Hawaii (Sterling et al. 2017).



Monthly Delivered and Curtailed PV Output in the CAISO System

Based on data obtained from CAISO

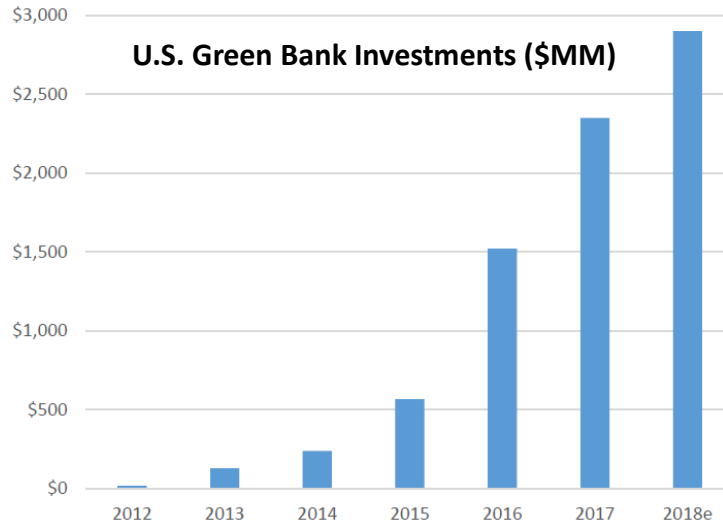
High-Resolution Imagery Used to Map U.S. PV



- Stanford researchers analyzed billions of high-resolution satellite images to identify the locations and sizes of solar PV panels in the contiguous United States, finding 1.47 million individual solar installations, including small rooftop, commercial, and utility-scale systems.
 - SEIA reported 1.82 million PV systems in the contiguous United States as of Q3 2018.
- Using these data, researchers looked at deployment information together with other variables and found that higher levels of deployment have occurred where:
 - Population density is 1,000 people per square mile, or greater
 - Solar radiation averages at least 4.5 $\text{kWh}/\text{m}^2/\text{day}$
 - Average annual household income is at or above \$150,000.
- The researchers also found that PV deployment decreases in areas with greater income inequality.
- The researchers argue this type of data could also be used to plan infrastructure upgrades, identify areas in need of solar deployment, or as a predictor model for adoption.
- The DeepSolar database was made publicly available to researchers, utilities, solar developers and policymakers.

Green Banks

- A green bank is a public, not-for-profit financial institution that leverages limited public dollars to drive private capital investment in clean power goods and services.
 - Green banks are designed to jump-start new markets, such as LMI solar, providing road maps and data to de-risk asset classes and allow other investors to enter.
 - Green banks can be established at the state (CA), county (Montgomery Country, MD), or city (New York City) level.

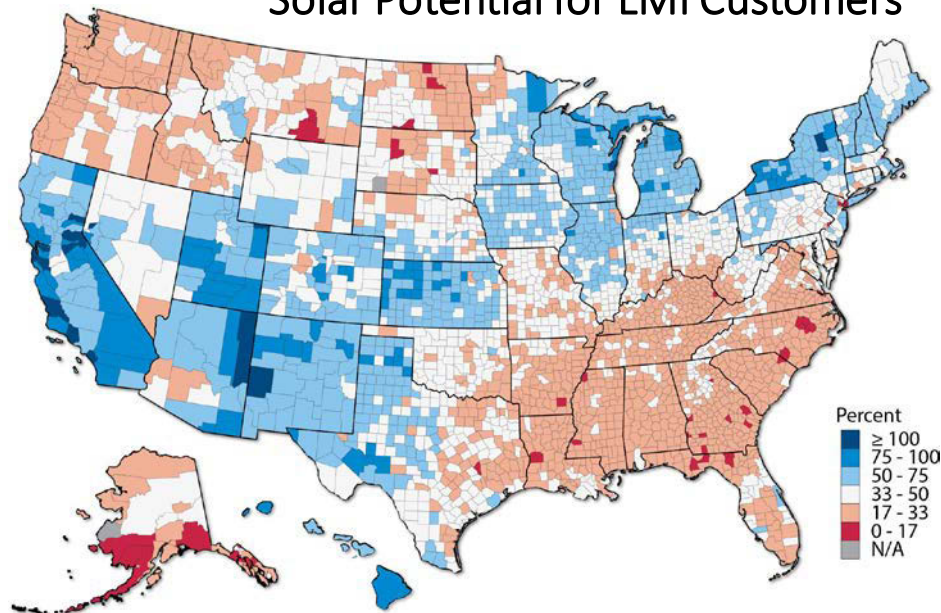


- The Green Bank Network, an international network of green banks, estimates green banks have made \$41B in transactions globally.
 - Green banks in Connecticut, New York, and Rhode Island are part of the international network.
- Over 15 green banks are currently operating in a dozen states in the United States.
 - The Coalition for Green Capital estimates these institutions mobilized \$3B in public and private capital for clean energy projects in 2018.
 - Some of these green banks have moved beyond state boundaries and are active in other states.
- In addition to green banks, traditional banks have started new efforts in sustainable finance.
 - In December 2018, Bloomberg announced the launch of the U.S. Alliance for Sustainable Finance—whose 15 founding members represent some of the largest banks in the world—with the mission of driving sustainable finance innovation.
 - These banks have over \$18.525B in assets on their balance sheet.

The Potential to Increase Solar Adoption for LMI Customers

- NREL estimates LMI rooftop solar technical potential is over 300 GW in the U.S. Sixty percent of the potential is on multifamily and renter-occupied buildings.
 - NREL surveyed LMI customers and found the two primary reasons for solar adoption to be being able to save on electricity bills and being influenced by their peers' actions.
- Randomized controlled trials in Connecticut, carried out by researchers at Yale, show that the decision to go solar by LMI adopters is influenced by social factors such as local events, effective solar ambassadors and town representatives, and connection to solar peers.
 - Visual exposure to solar (especially seeing a solar rooftop project from the street) increased the average number of installations within a half-mile radius by nearly 50%.
 - In communications campaigns, individual-oriented messages focusing on personal financial benefits, including the stabilization of energy bills, yielded higher solar installation rates.

Solar Potential for LMI Customers



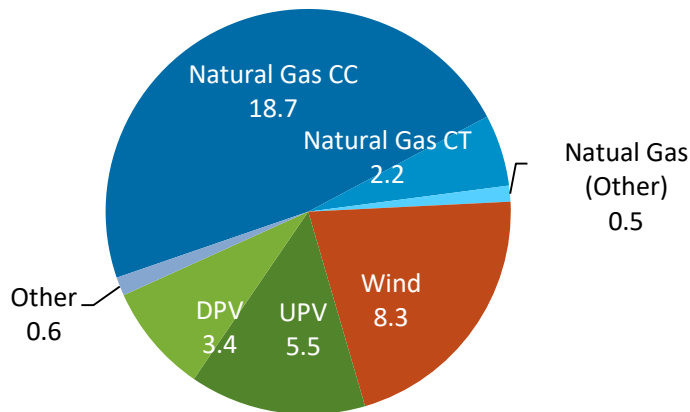
Percentage of LMI electricity consumption offsettable by rooftop solar using only single family owner-occupied buildings' roofs

U.S. Generation Capacity Additions by Source: 2017 and *Estimated* 2018

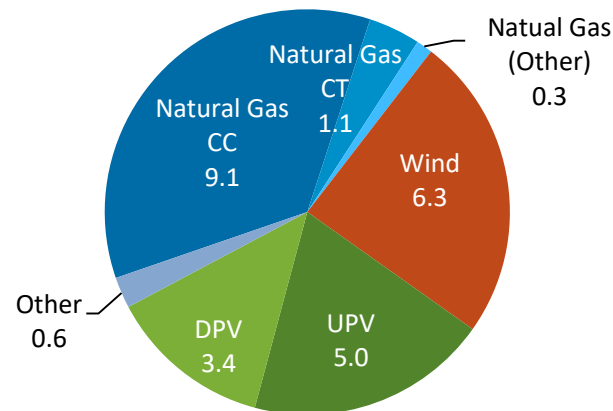
- EIA estimates 23% of all new electricity generating capacity came from solar installations in 2018—second to natural gas.
- Based on data through October 2018, solar capacity additions are expected to increase y/y.
- 2018 will likely be the first year since 2013 that solar and wind represented less than 50% of annual generation capacity additions.

- Based on EIA data through October 2018, it is estimated that 39 GW of new electric generating capacity came online in 2018—up from 25.9 GW in 2017.
 - 24.7 GW came online from January through October 2018, and another 14.6 GW (37%) is estimated to have come online in November and December.
 - A large part of this increase is due to the expected addition of 21 GW of natural gas plants—up from 10.5 GW in 2017.
 - Wind additions are expected to also have increased by one-third as well.

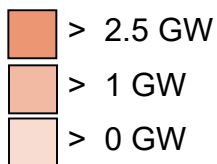
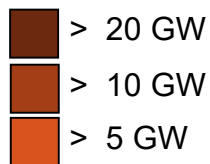
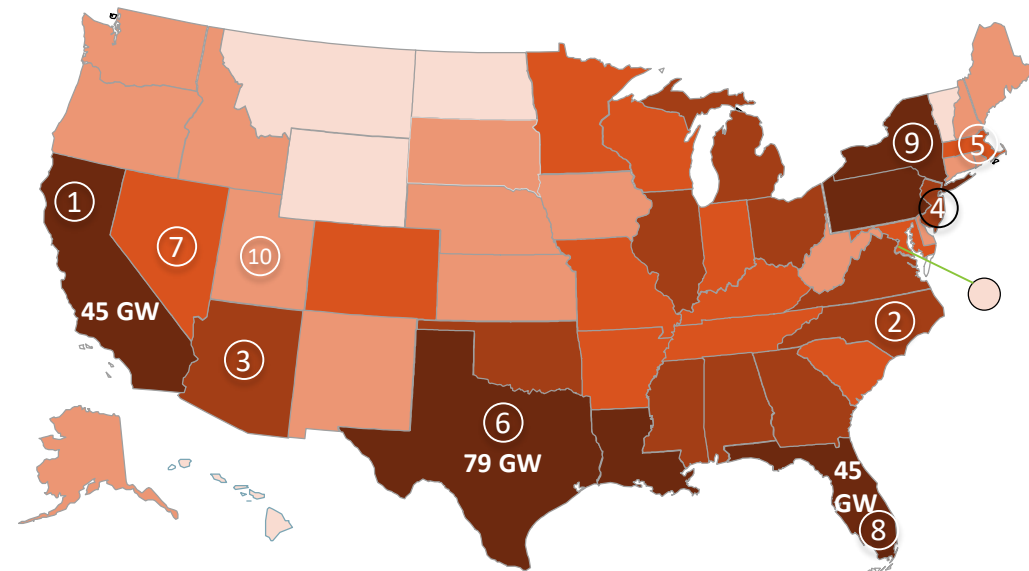
***Estimated* 2018 U.S. Generation Capacity Additions
(Total 39.3 GW)**



**2017 U.S. Generation Capacity Additions
(Total 25.9 GW)**



Total Installed Natural Gas Electric Generating Capacity

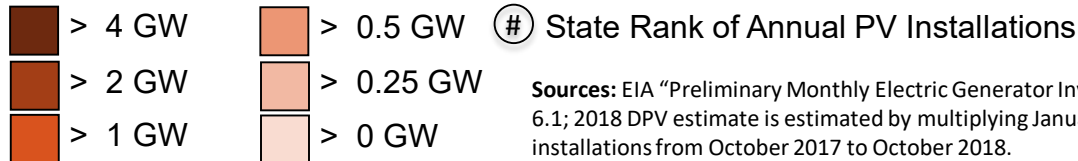
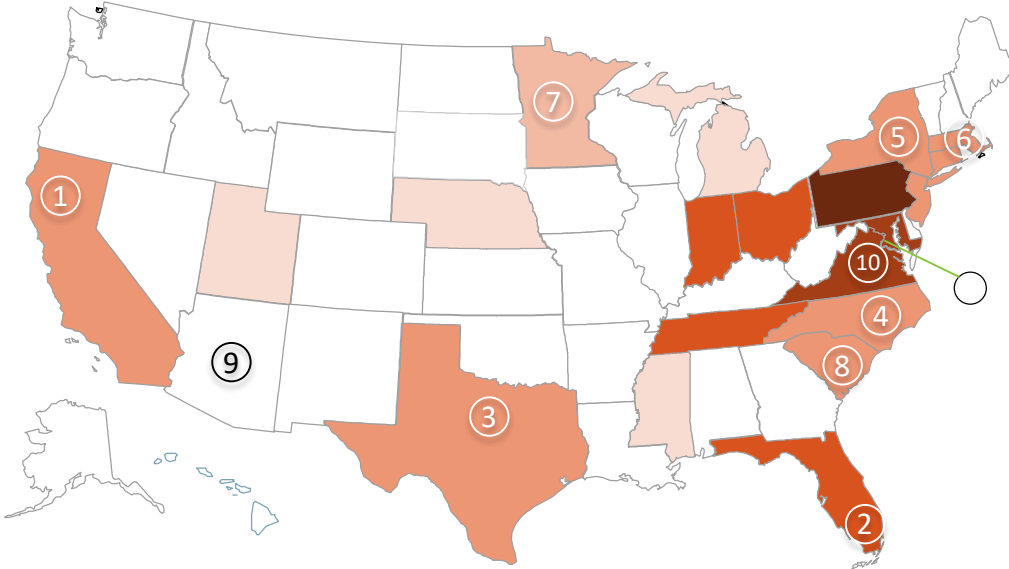


State Rank of Cumulative PV

Sources: EIA “Preliminary Monthly Electric Generator Inventory. solar: EIA, “Electric Power Monthly” Table 6.1; 2018 DPV estimate is estimated by multiplying January – October installations by 12/10. PV Rank as of October 2018.

- At the end of October 2018, the United States had a cumulative electric generating capacity of approximately 538 GW of natural gas facilities, with 31% of that being in Texas, California, and Florida.
- Most states with significant levels of PV also have significant natural gas electric generation capacity.

Estimated 2018 Natural Gas Electric Generating Capacity Additions



Sources: EIA “Preliminary Monthly Electric Generator Inventory. solar: EIA, “Electric Power Monthly” Table 6.1; 2018 DPV estimate is estimated by multiplying January – October installations by 12/10. PV Rank as of installations from October 2017 to October 2018.

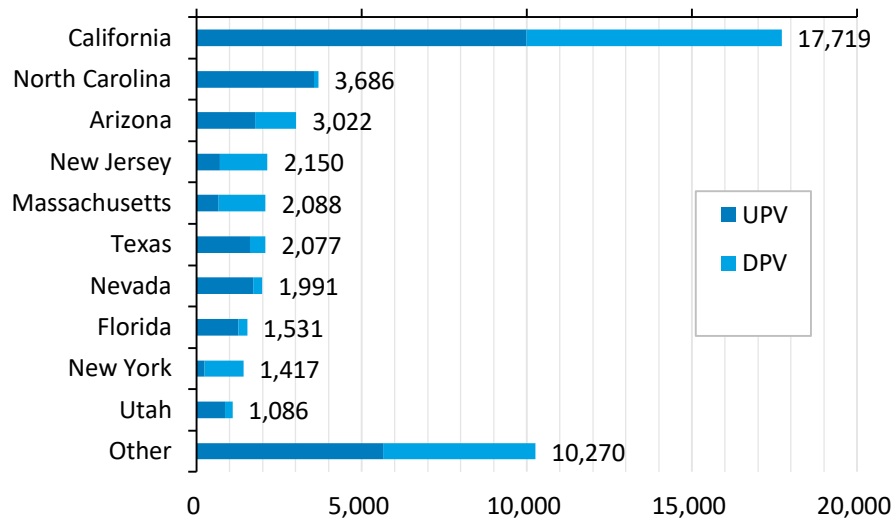
- An estimated 21 GW of natural gas electric generation capacity was added in 2018—approximately 4% of total natural gas electric generation capacity.
 - An estimated 18% of total U.S. PV capacity was added in 2018.
- From October 2017 to October 2018, most states with significant levels of PV deployment also had significant natural gas electric generation deployment.

U.S. Installation Breakdown by State

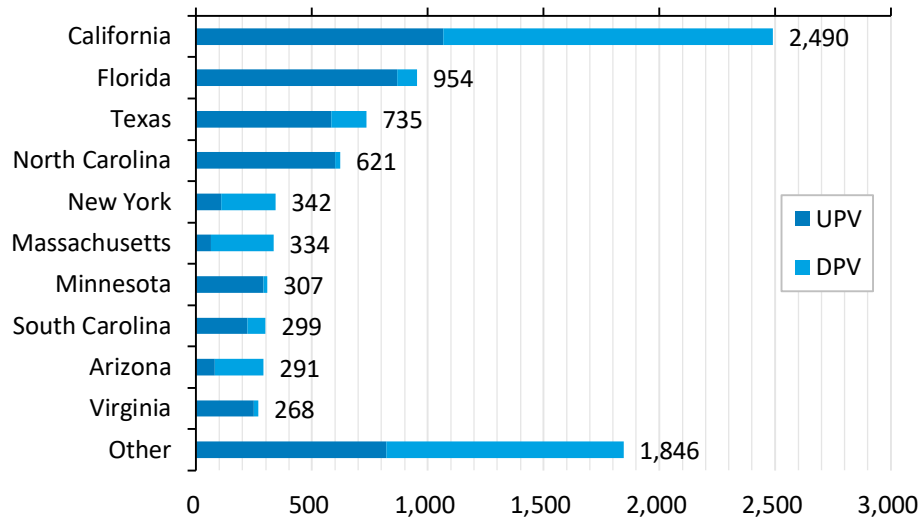
At the end of October, there were 47.0 GW-AC of solar systems in the United States, of which 28.0 GW were utility-scale PV and 19.0 GW were distributed PV.

From October 2017 to October 2018 approximately 8.5 GW-AC of PV capacity was installed, of which 5.0 GW-AC were utility-scale PV and 3.5 GW-AC were distributed PV.

Cumulative Installed Capacity, Top 10 States as of Oct. 2018
Megawatts (MW-AC)



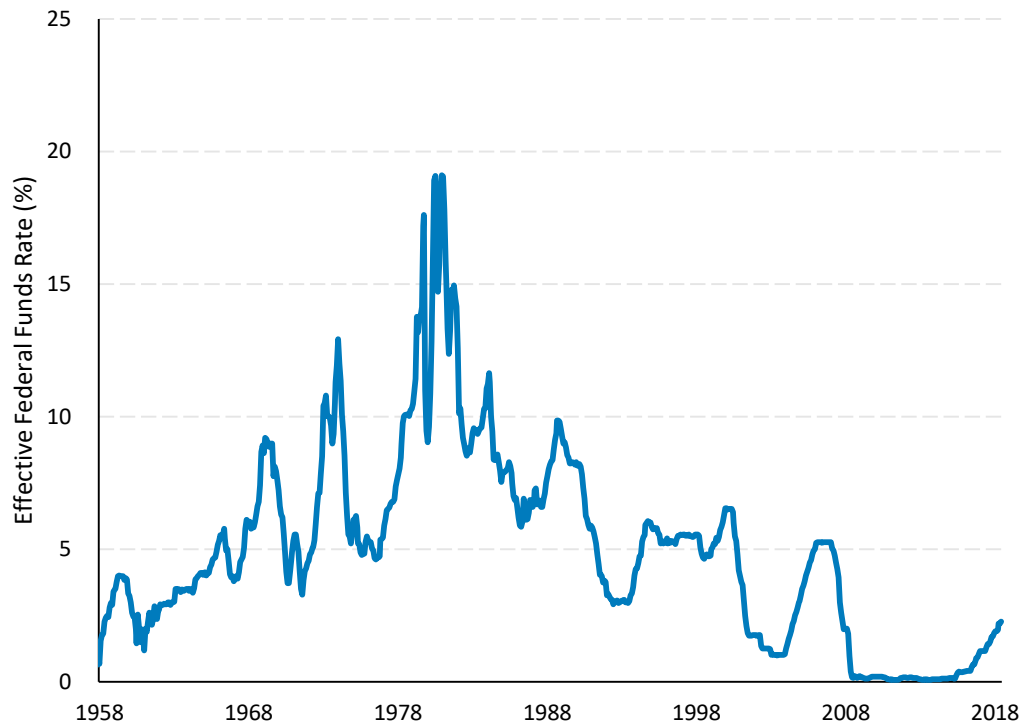
Installed Capacity, Top 10 States, from Oct. 2017 to Oct. 2018
Megawatts (MW-AC)



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.

Sources: EIA, "Electric Power Monthly," forms EIA-023, EIA-826, and EIA-861 (December 2018).

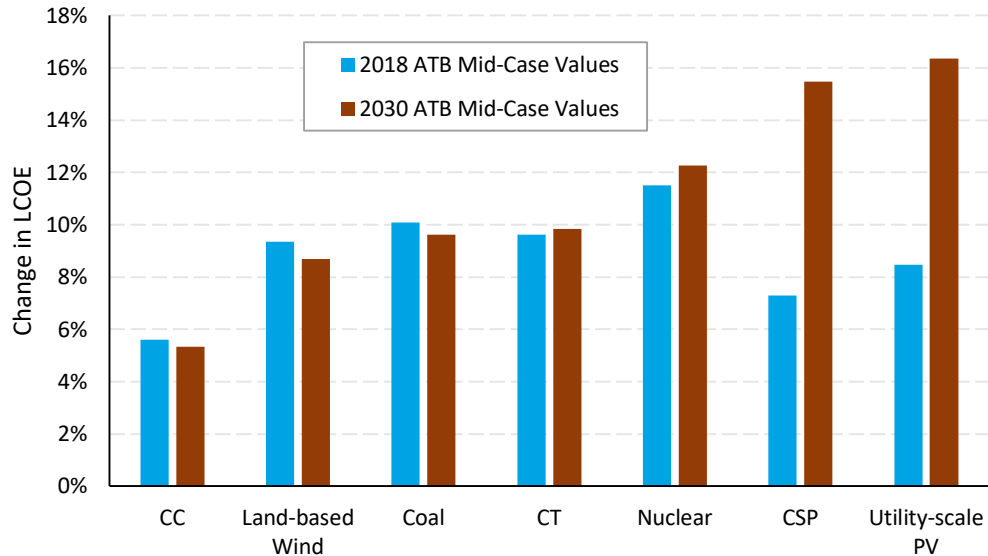
Historical U.S. Interest Rates



- The vast majority of U.S. PV installations have occurred in a historically low-interest rate environment.
- The Federal Funds Rate, which influences virtually all borrowing rates in the United States, has increased by 1.9% in the past 18 months; however, it is still at a relatively low historical level.
- Some within the solar industry worry further increases in interest rates could dampen solar deployment or could require further reductions in system costs to achieve the same levels.

Impact of Interest Rate Changes by Energy Technology

LCOE Impact of a 3% Increase in Interest Rates



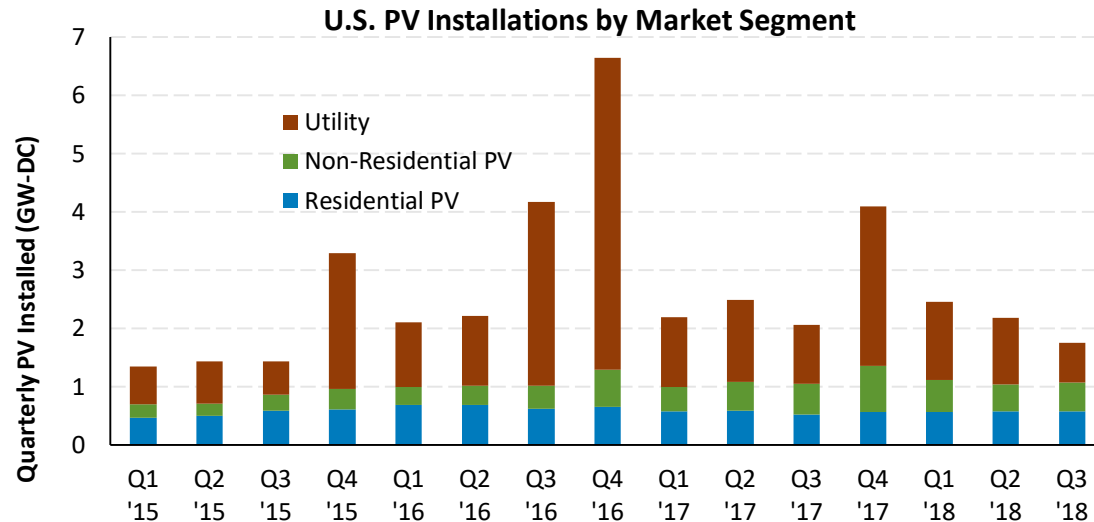
Note: The analysis uses the “mid-case” and “market factor financials” for each technology.

Source: NREL 2018 Annual Technology Baseline (ATB): <https://atb.nrel.gov/>.

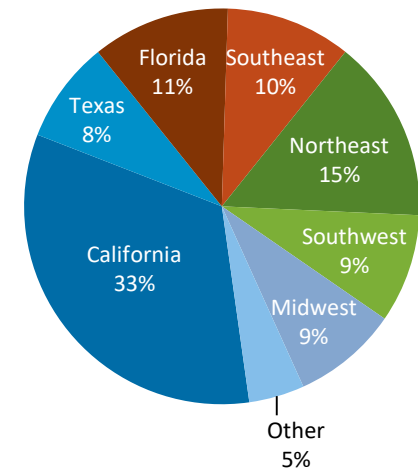
- An analysis was performed using NREL’s 2018 Annual Technology Baseline (ATB), in which interest rates were increased 3% for each technology.
- In 2018, solar tended to be less impacted by an increase in interest rates than other technologies.
 - The tax credit reduced the impact that upfront capital costs had on LCOE.
 - The need for tax equity investors resulted in a lower level of debt, dampening the impact of an increase in interest rates.
- However, by 2030, assuming no incentives and a higher level of debt, solar technologies were projected to be impacted the most by an increase in interest rates.
- The impact of an increase in interest rate depends on the proportion that upfront capital costs, O&M, incentives, and fuel have on LCOE, as well as the percent of debt a technology can raise for a project.
- Note that fuel costs and O&M are also likely to increase with a long-term interest rate environment, which is not captured in the analysis.

U.S. Installation Breakdown

- In Q3 2018, the United States installed 1.8 GW-DC of PV, down 15% y/y.
 - Thirty-nine percent of capacity came from utility PV—the lowest level since Q1 2012.
 - Wood Mackenzie attributes the low level of utility-scale installation to uncertainty of the impacts of the Section 201 tariff in 2017.
 - Since late 2015, the United States has installed approximately 1 GW-DC of distributed PV each quarter.
 - More than 400 MW-DC of community solar was installed during the first nine months of 2018.

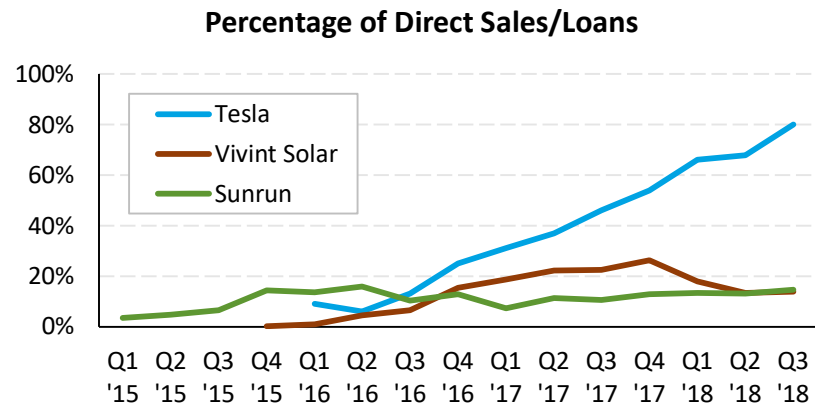
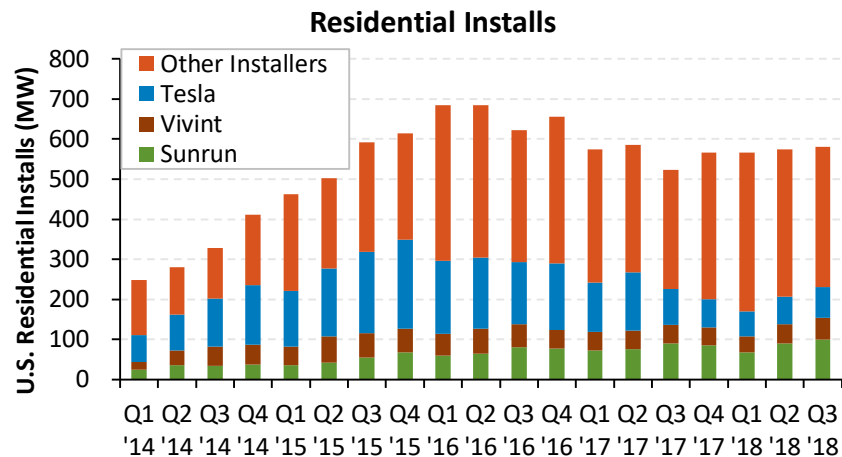


**U.S. PV Installations by Region (MW-DC)
Q1 - Q3 2018**



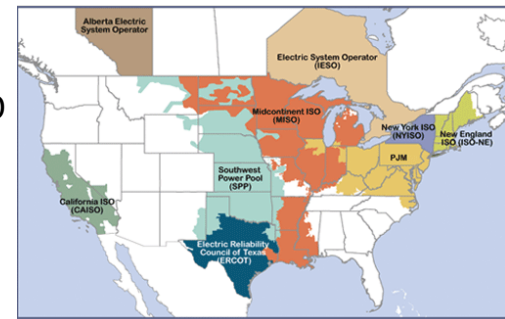
Tesla, Vivint Solar, and Sunrun Residential Market Share

- A modest increase in U.S. residential installations in Q3 2018 was led in large part by increases in large national installers.
- Tesla's direct sales continue to grow as a percentage of total sales, while Sunrun and Vivint still install mostly leased or PPA systems.
 - Vivint recently switched its commission incentive structure to favor TPO over customer-owned sales.
 - Wood Mackenzie also reports that business for the largest residential PV loan providers has slowed due to tightening credit requirements, rising interest rates, and a desire to achieve profitability.

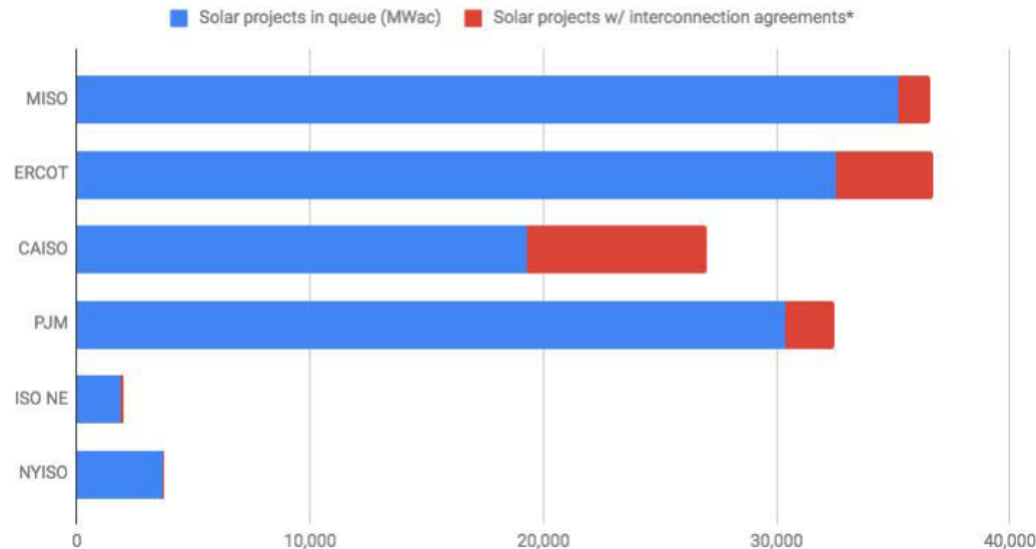


U.S. Utility-scale Solar Set to Take Off

Map of ISO territories

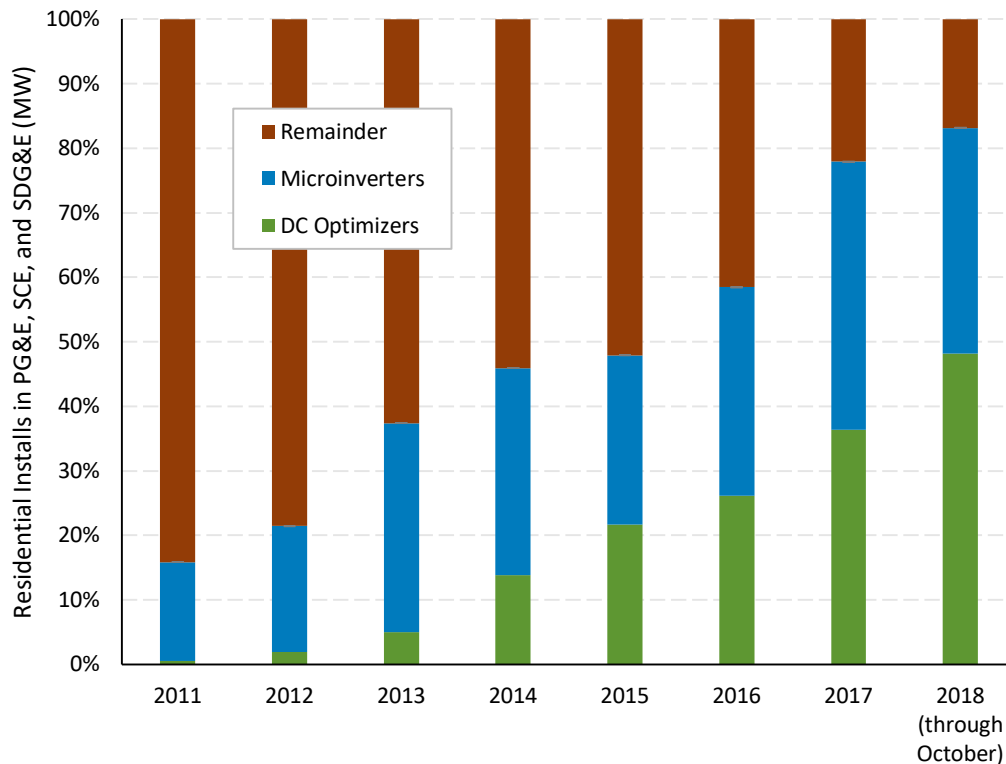


Solar projects by Independent System Operator (ISO) queue



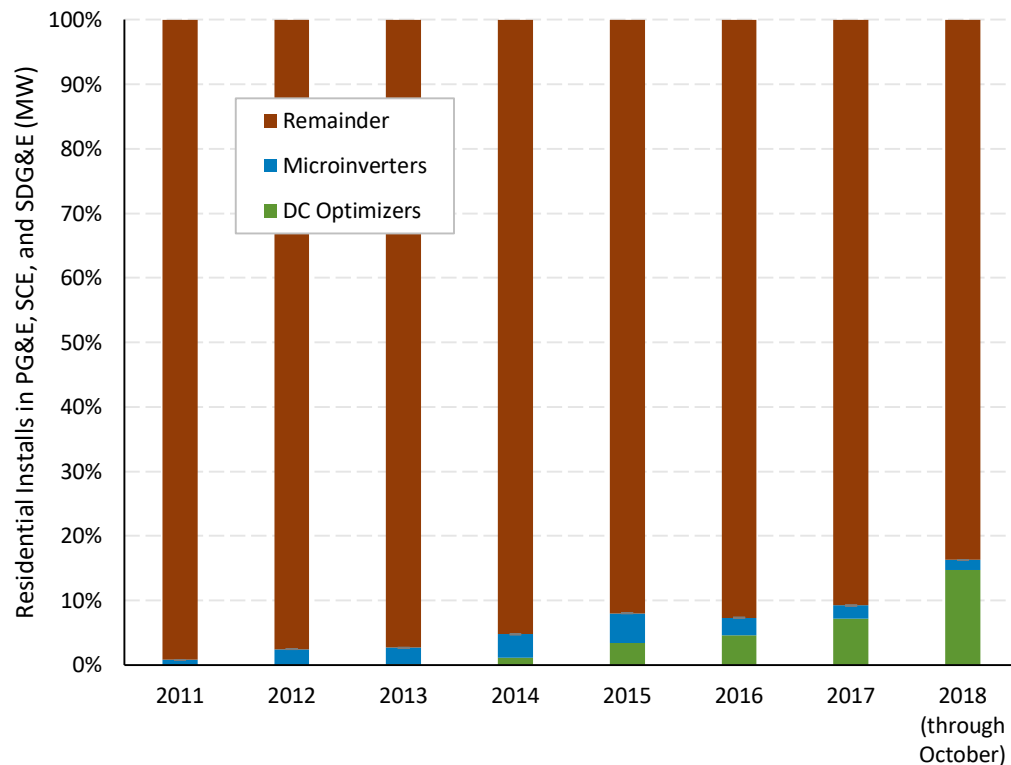
- PV Magazine reports that developers have applied to build 139 GW-AC of utility-scale PV systems in six grid-operating territories.
 - This figure does not include projects in most of the South, Mountain West, Pacific Northwest, and Plains States.
- However, ISO New England estimates 70% of the projects in its queue are never completed. Several factors can contribute to projects dropping out of the queue. For example:
 - Interconnection upgrades may be cost prohibitive.
 - Projects may be unable to finalize power sales contracts or financing.

California Residential MLPE



- MLPE continue to gain market-share in the U.S. residential PV market, with 83% of residential systems in California using a micro-inverter or DC optimizer in 2018.
 - An important factor in the shift to MLPE in the California residential PV sector was a change in building codes requiring “rapid shutdown” of PV output. Other states have adopted similar measures.
- The vast majority of systems either use SolarEdge (DC optimizers) or Enphase (micro-inverters).
 - SunPower had gained significant market share in the microinverter space but has since sold its inverter business to Enphase.

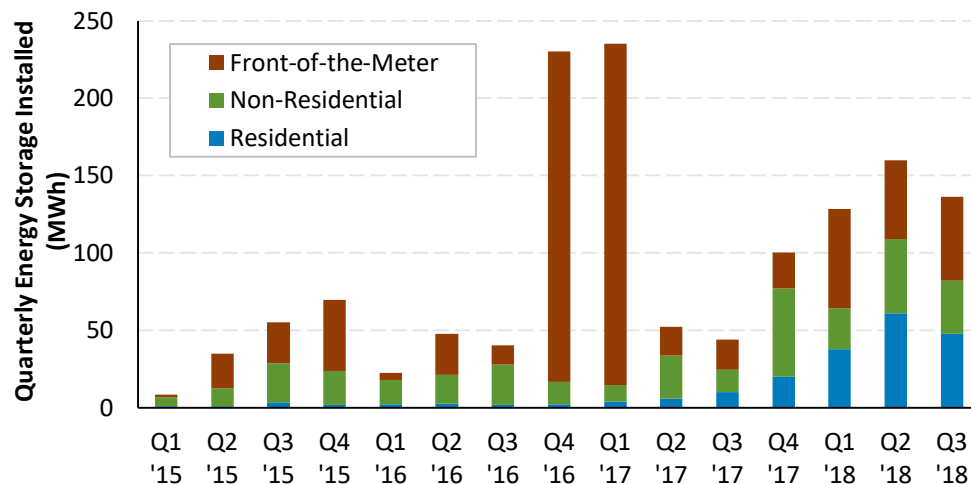
California Non-Residential MLPE



- MLPEs are less common in the non-residential PV market; however, they are becoming more common in non-residential systems, too.
 - The share of MLPEs in the California non-residential PV market reached approximately 17% in 2018.

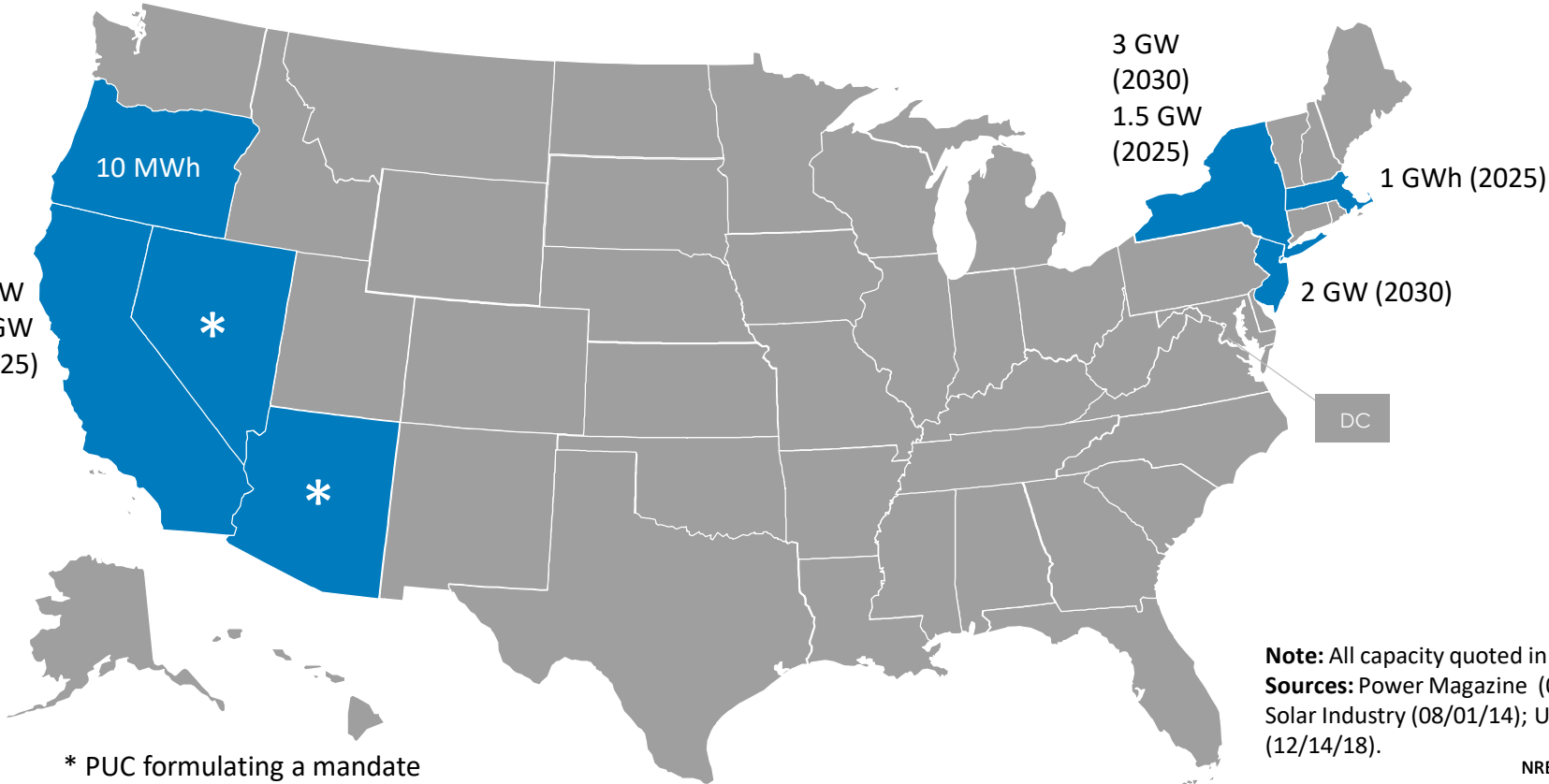
U.S. Energy Storage Installations by Market Segment

- The United States installed approximately 425 MWh (169 MW) of energy storage onto the electric grid in the first nine months of 2018—up 28% y/y, despite the Q1 2017 front-of-the-meter spike.
 - The drop in behind-the-meter storage installations, Q/Q, was attributed to battery supply constraints. Still, it was the second-largest quarter on record.



- Of the behind-the-meter storage capacity deployed in Q3 2018, 70% and 10% occurred in California and Hawaii respectively.
- Massachusetts is expected to have a large storage market in 2019 due to the rollout of its SREC successor program, SMART. The program provides \$0.03/kWh–\$0.08/kWh for storage systems paired with PV that have a discharge duration of at least two hours, have a roundtrip efficiency of at least 65%, and which discharge at least 52 cycles annually.
- In July 2018, California revised its fire code to set more stringent standards on stationary storage using lithium-ion batteries. The changes are expected to add costs to certain systems and make others infeasible.
- Outside the major markets, only a few places have policies in place to provide revenue streams that make solar-plus-storage viable.

U.S. PV Deployment: States with Energy Storage Mandates



Note: All capacity quoted in W-AC.
Sources: Power Magazine (03/01/18); Solar Industry (08/01/14); UtilityDive (12/14/18).



- 1 State and Federal Updates

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- 3 U.S. PV Deployment

- 4 PV System Pricing**

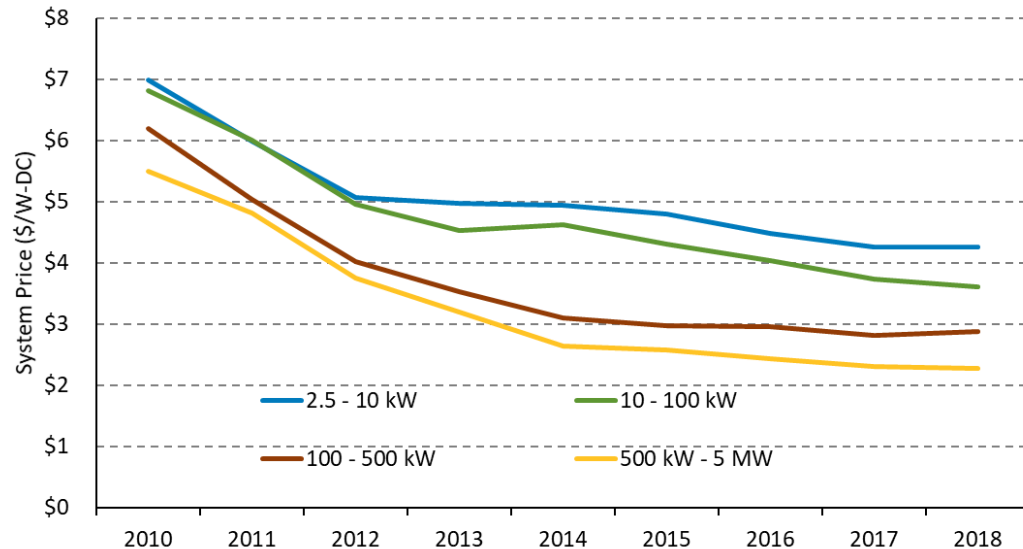
- 5 Global Manufacturing

- 6 Component Pricing

- 7 Market Activity

Based on preliminary reported data, from 2017 to 2018, the median reported PV system price in California, Massachusetts, and New York was relatively flat, though significant price variation remains.

System Pricing from Select States



Based on preliminary data, from 2017 to 2018, the median reported PV system price in California, Massachusetts, and New York:

- Remained flat at \$4.25/W for systems from 2.5 kW to 10 kW
- Fell 3% to \$3.61/W for systems from 10 kW to 100 kW
- Increased 2% to \$2.88/W for systems from 100 kW to 500 kW
- Fell 1% to \$2.27/W for systems from 500 kW to 5 MW.

Preliminary 2018 MW: CA (657), MA (218), NY (256)

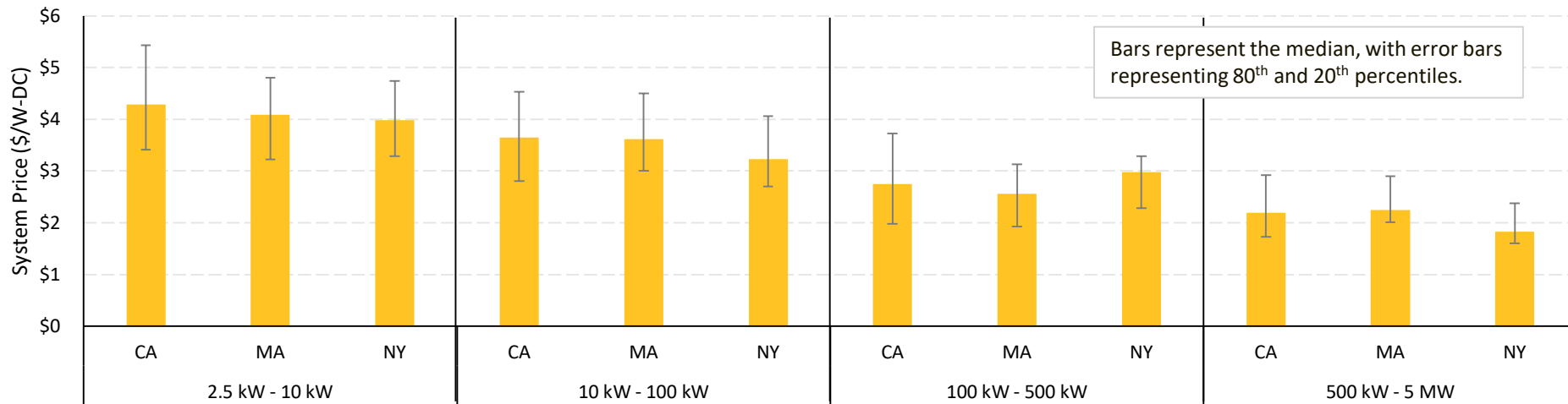
Note: System prices above \$10/W and below \$1/W were removed from the data set.

Sources: CA NEM database (10/31/18); MA SREC program (12/12/18); NYSEDA (11/30/18).

System Pricing from Select States, 2018 (Preliminary)

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

- Based on preliminary data in 2018, the median price of a small system in New York was about 8% less than the median price in California.
- In 2018, the 20th and 80th percentile preliminary prices in California for a small system were \$3.46/W and \$5.43/W respectively.



Preliminary 2018 MW: CA (657), MA (218), NY (256)

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

Sources: CA NEM database (10/31/18); MA SREC program (12/12/18); NYSEDA (11/30/18).



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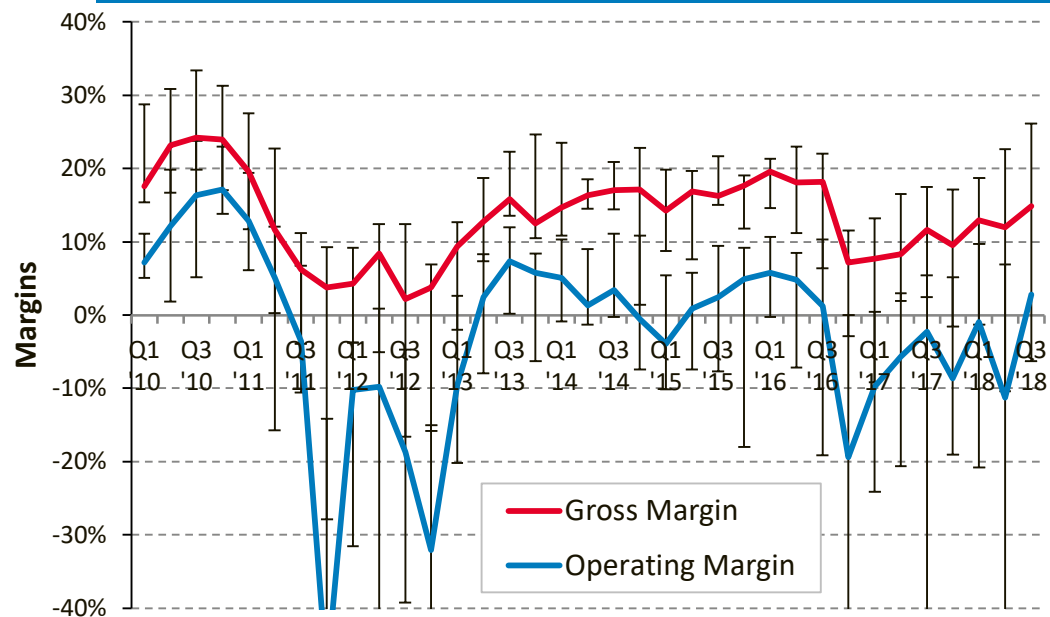
5 Global Manufacturing

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7 Market Activity

- Performance of solar companies was mixed in Q3 2018, improving on average due to successfully transitioning to low-cost environment.
- Three gigawatts of announced new or refurbished U.S. PV manufacturing capacity is expected to come online in 2019. **Peak capacity may also be lower than originally reported, or manufacturers may take time to ramp up to full production.**

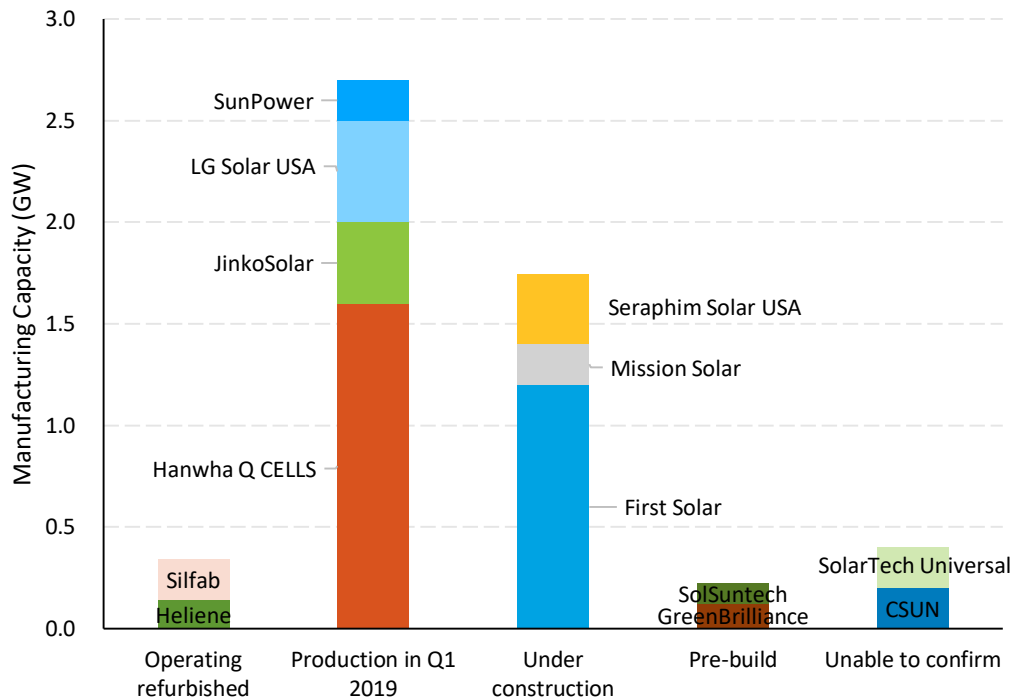
PV Manufacturers' Margins



Line represents the median, with error bars representing 80th and 20th percentiles for the following companies in Q3 2018: Canadian Solar, First Solar, Hanwha Q Cells, Hareon Solar, HT-SAAE, Jinko Solar, LONGi, Motech Industries, Neo Solar Power, Renesola, and SunPower. Margin data from JA Solar, Trina, and Yingli are also included from Q1 2010 to Q2 2018 where available.

- Performance of solar companies was mixed in Q3 2018, improving on average due to successfully transitioning to low-cost environment.
 - The median operating margin for the 11 solar companies analyzed was positive for the first time since Q3 2016.
 - First Solar reported good performance in Q3 2018, with their advanced, lower-cost panels (Series 6) commencing shipments from its factory in Vietnam.
 - Some module companies (e.g., Canadian Solar) have benefited from lower supply-chain costs (e.g., polysilicon costs).

2018 U.S. PV Manufacturing Expansion



- Solar Power World reports that approximately 340 MW of U.S. manufacturing capacity was refurbished in 2018 and is now currently operating.
- Roughly 2.7 GW of new or refurbished U.S. PV manufacturing capacity is expected to come online in Q1 2019, and an additional 1.7 GW is under construction.
 - Historically, actual production capacity brought online has often taken longer and/or been lower than originally reported.
- An additional 600 MW of U.S. PV manufacturing capacity expansion, which was announced, has not yet started construction.



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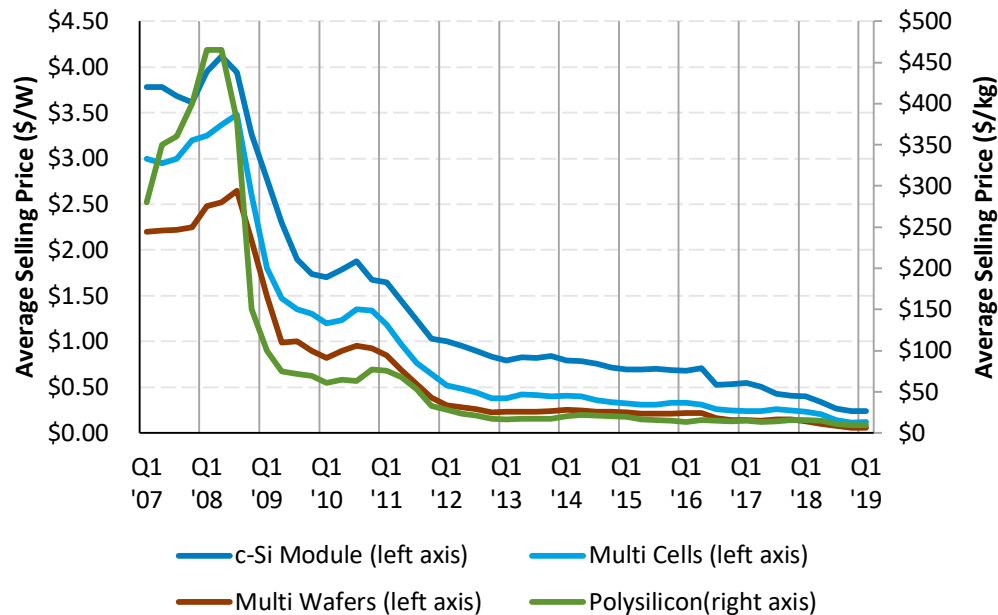
5 Global Manufacturing

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- Global module and module-component prices have dropped 94% to 97% in the past 12 years, 53% to 77% in the past five years, and 39% to 53% in the last year.
- PVinsights reports that global PV module prices dropped from \$0.31/W to \$0.22/W in 2018.

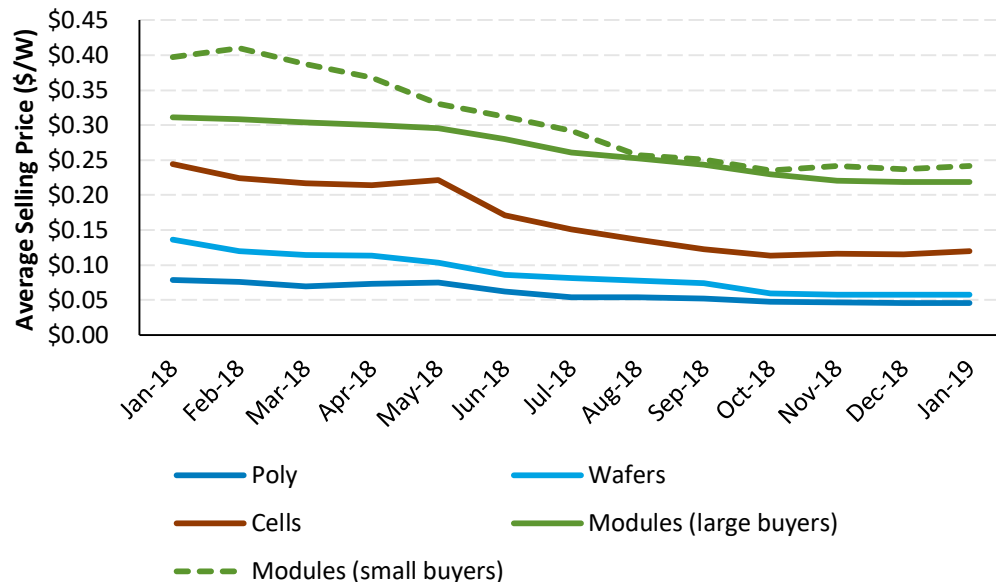
PV Value Chain Spot Pricing Q1 2007–Q1 2019



Global module and module-component prices have dropped 94% to 97% in the past 12 years, 53% to 77% in the past five years, and 39% to 53% in the last year.

Sources. Barclays (12/14/09); BNEF Solar Spot Price Index, accessed 01/18/19; UBS (2/12/10, 4/23/10, 7/27/10, 10/29/2010, 1/24/11, 6/3/11, 6/16/11, 8/17/11, 9/16/11, 12/12/11, 1/20/12, 2/13/12, 4/19/12).

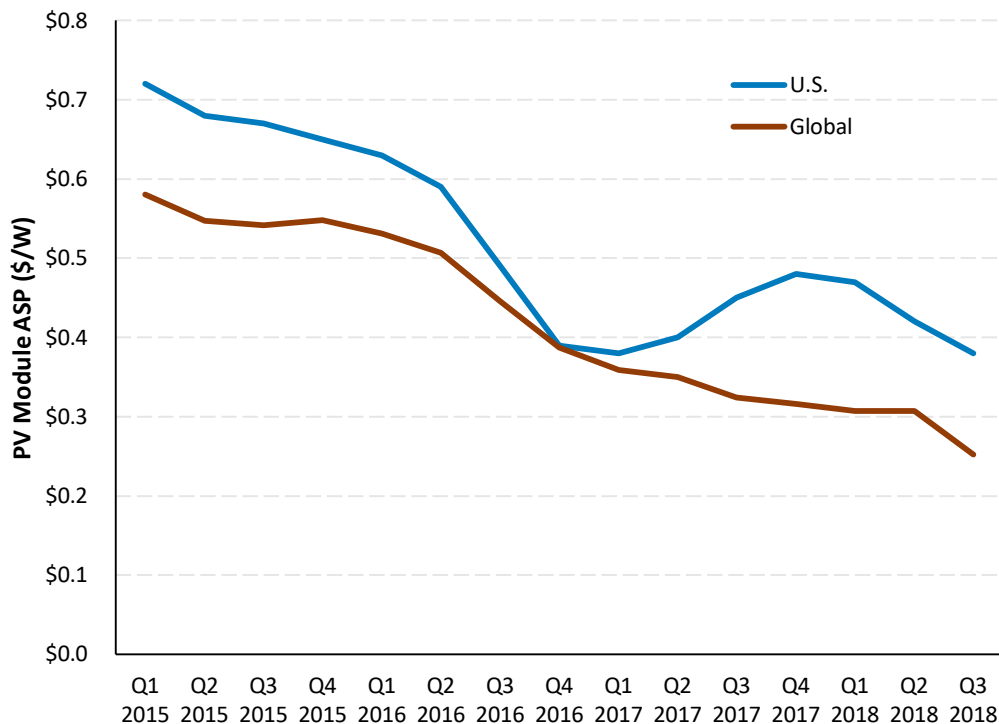
PV Value Chain Spot Pricing, 2018



- While global module and module-component prices dropped significantly in 2018, they were relatively flat in Q4.
 - PVinsights reports that global PV module prices dropped from \$0.31/W to \$0.22/W in 2018.
 - BNEF reports that, in 2018, cells dropped from \$0.24/W to \$0.12/W, wafers dropped from \$0.14/W to \$0.06/W, and polysilicon dropped from \$16.6/kg to \$9.6/kg (\$0.08/W to \$0.05/W).

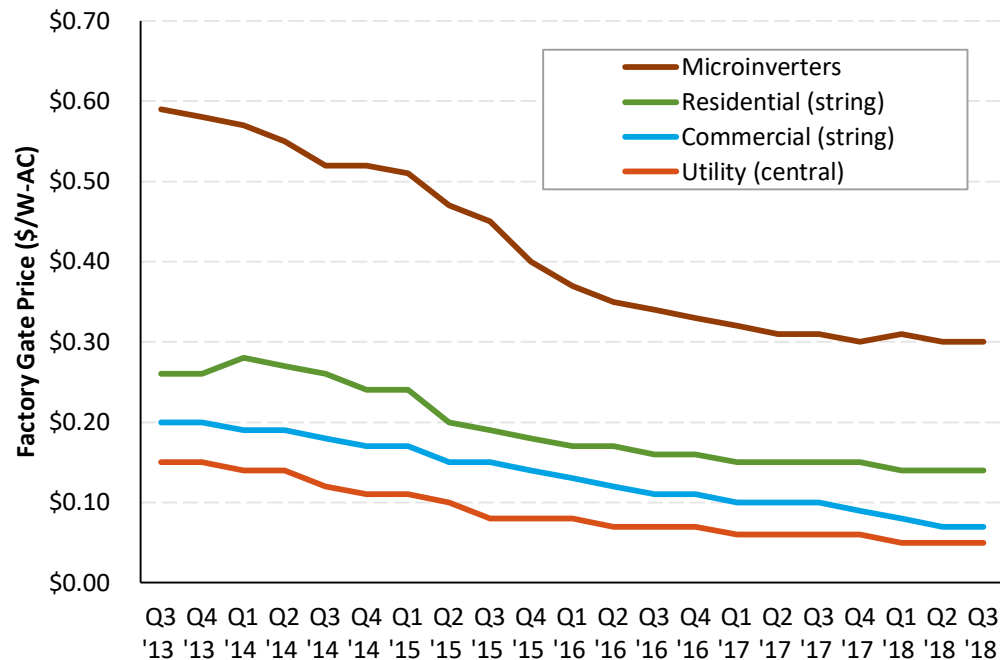
Sources. “Modules (large buyers)” from PVinsights, accessed 01/18/19. Remaining pricing data from BNEF Solar Spot Price Index (01/18/19). Kilogram to Watt conversion: 4.78 grams per watt (2016); 4.73 grams per watt (2017, 2018, 2019), from Cowen & Co. (05/11/17); Deutsche Bank (07/19/17).

Module Average Selling Price: Global versus United States



- In Q3 2018, U.S. module prices continued to fall, dropping to their lowest recorded levels, but they were still trading at a significant premium over global module ASP.
 - Modules sold in the United States in Q3 2018 were 21% lower in price than modules sold in the United States in Q4 2017 but 51% higher in price than the global average.

Inverter Pricing



U.S. inverter pricing was relatively flat in Q3 2018, though it was still trading at historical lows.



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5 Global Manufacturing

6 Component Pricing

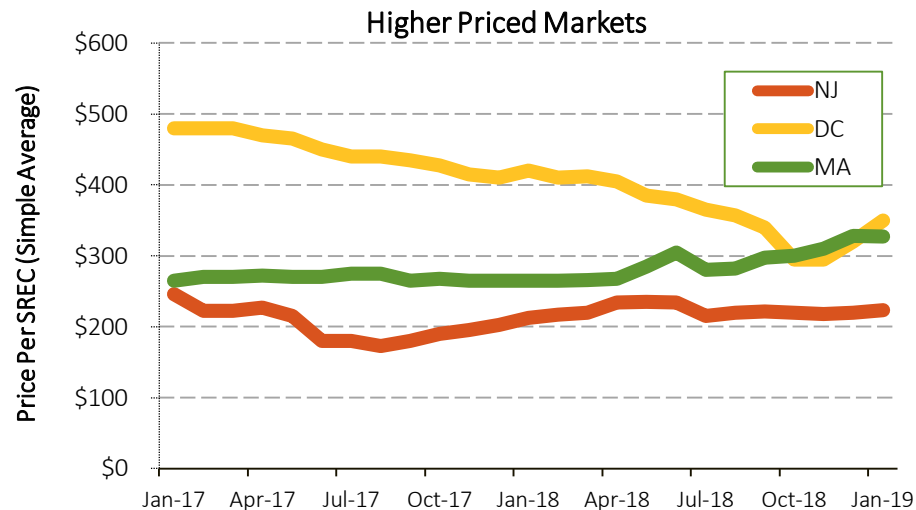
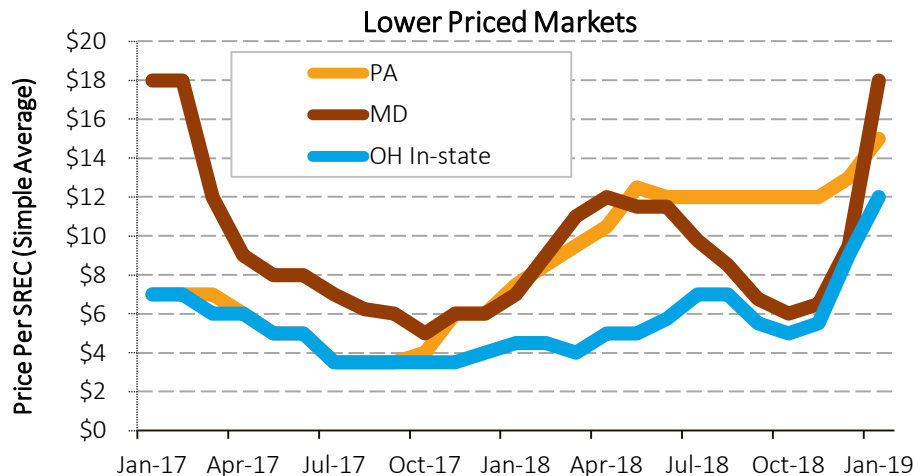
7 Market Activity

- SREC pricing rose in virtually all markets in the second half of 2018, as some markets are in undersupply, and others have been buoyed by proposed or enacted legislation.
- At the end of October 2018, solar stocks were down 30% for the year, compared to 5% for the broader market.
- In 2018, solar stocks were down 28% compared to -1% performance by the S&P 500 Index.
- 2018 global and U.S. solar investment were \$132B and \$21B respectively, the vast majority of which went to project deployment.

SREC Pricing

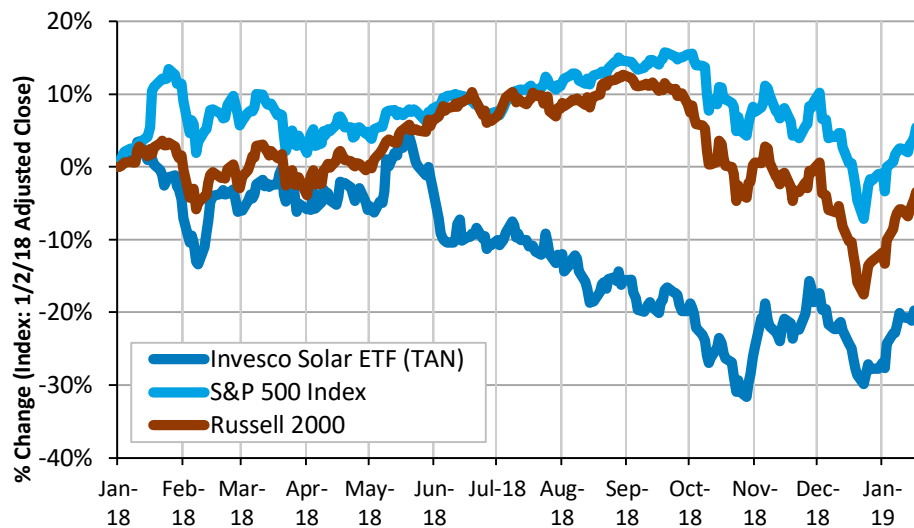
- SREC pricing rose in all markets in the second half of 2018.
 - Some of these markets are in undersupply, but many have been buoyed by proposed or enacted legislation, raising RPSs.

- In December 2018, Washington D.C. unanimously approved legislation mandating 100% renewable electricity by 2032.
- As of December 2018, a veto-proof majority of legislatures had pledged support for a Maryland bill doubling their RPS to 50% by 2030.



Stock Market Activity

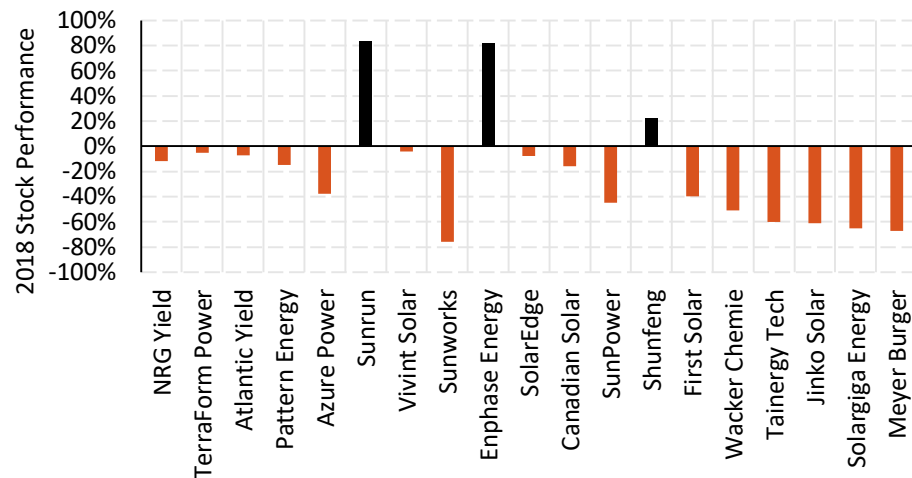
- In 2018, many solar stock prices plummeted after the Chinese announcement in late May of a decrease in subsidies, causing an oversupply of PV modules and cells in the marketplace.
- In Q4 2018 and January of 2019, solar stocks followed the general marketplace, recovering 10% of their losses from December 24, 2018 to January 16, 2019.



Source: Stock market: Yahoo Finance (01/19/19); Mercom (01/19/19).

- While most solar stocks performed poorly in 2018, installers tended to perform better than manufacturers.

2018 Solar Stock Performance

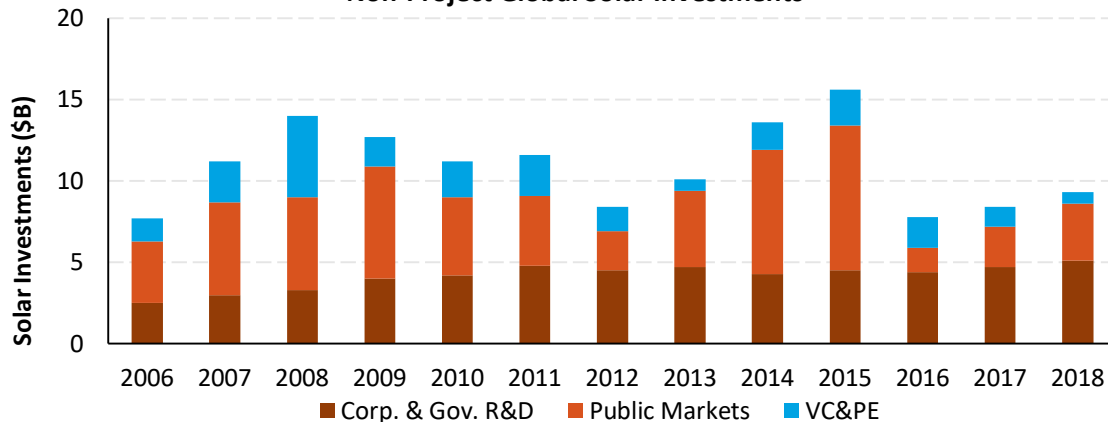


Global Solar Investments

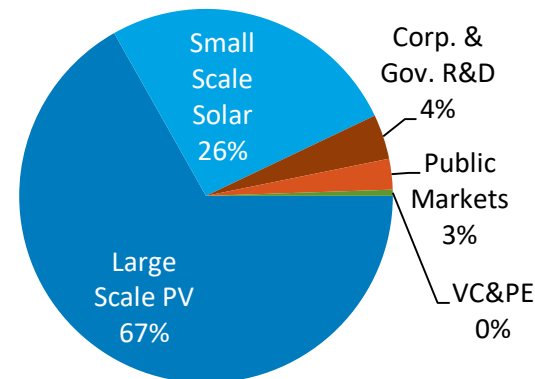
- In 2018, non-project global solar public market investments grew 35% y/y but were still well below 2013–2015 levels.
- In 2018, global VC&PE investments in solar approached their lowest levels since 2006.
- The largest solar public market deal in 2018 was a \$808MM IPO of the French PV developer Neoen SA.

- Since 2011, global investments in solar energy have been approximately \$150B per year.
- The majority of global investment in solar has historically gone to funding of projects—94% in 2018.
- Global government and corporate solar R&D, which has been \$4B–\$5B since 2009, set a record in 2018 with \$5.1B in spending.
- Public markets and VC&PE have varied significantly more over time, with a significant increase in public markets in 2013–2015 going toward yieldcos (e.g., Terraform and 8point3) and third-party residential companies (e.g., SolarCity and SunPower)—both of which were lower since 2016.

Non-Project Global Solar Investments

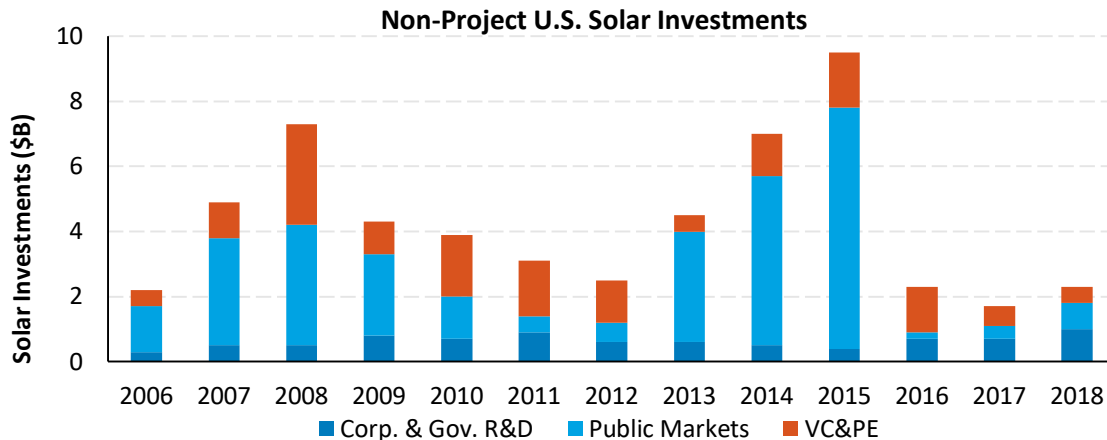


2018 Global Solar Investments (\$132B)



U.S. Solar Investments

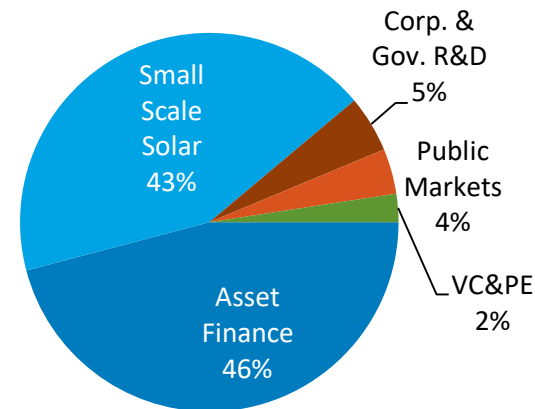
- U.S. public markets in 2013–2015 raised funds for yieldcos (e.g., Terraform and 8point3) and third-party residential companies (e.g., SolarCity, SunPower)—but dropped precipitously in 2016.
 - The largest U.S. solar deal in 2018, was the \$650MM in a Private Investment in Public Equity transaction by TerraForm.
 - Most other public market raises were significantly smaller.



Source: BNEF, "Clean Energy Investment Trends 2018."

- In December 2018, the CEO and founder of 8minuteenergy, a utility-scale development company, completed the sale of his 50% stake in the company to his cofounder for \$200MM.
- Total U.S. investments in solar energy remained relatively flat, y/y, at approximately \$21B.
- The majority of U.S. investment in solar has historically gone to funding of projects—90% in 2018.

2018 U.S. Solar Investments (\$21B)



Thank You

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List of Acronyms and Abbreviations

• AC	alternating current	• NEM	net energy metering
• ASP	average selling price	• O&M	operations and maintenance
• B	billion	• PPA	power purchase agreement
• BNEF	Bloomberg New Energy Finance	• PV	photovoltaic
• CSP	concentrating solar power	• R&D	research and development
• DC	direct current	• Q	quarter
• EIA	U.S. Energy Information Administration	• REC	renewable energy certificate
• ETF	exchange traded fund	• RPS	renewable portfolio standards
• GW	gigawatt	• S&P	Standard and Poor's
• GW-th	gigawatt-thermal	• SEIA	Solar Energy Industries Association
• IOU	investor-owned utility	• SETO	Department of Energy Solar Technology Office
• IPO	initial public offering	• SREC	solar renewable energy certificate
• ISO	independent system operator	• TAN	Invesco Solar ETF
• kg	kilogram	• TPO	third-party owner
• kW	kilowatt	• TWh	terawatt-hour
• LCOE	levelized cost of energy	• UPV	utility-scale PV
• LMI	low and moderate income	• VC&PE	venture capital and private equity
• m ²	meter-squared	• W	watt
• MLPE	module-level power electronics	• y/y	year over year
• MM	million	• YTD	year to date
• MW	megawatt		
• MWh	megawatt-hour		